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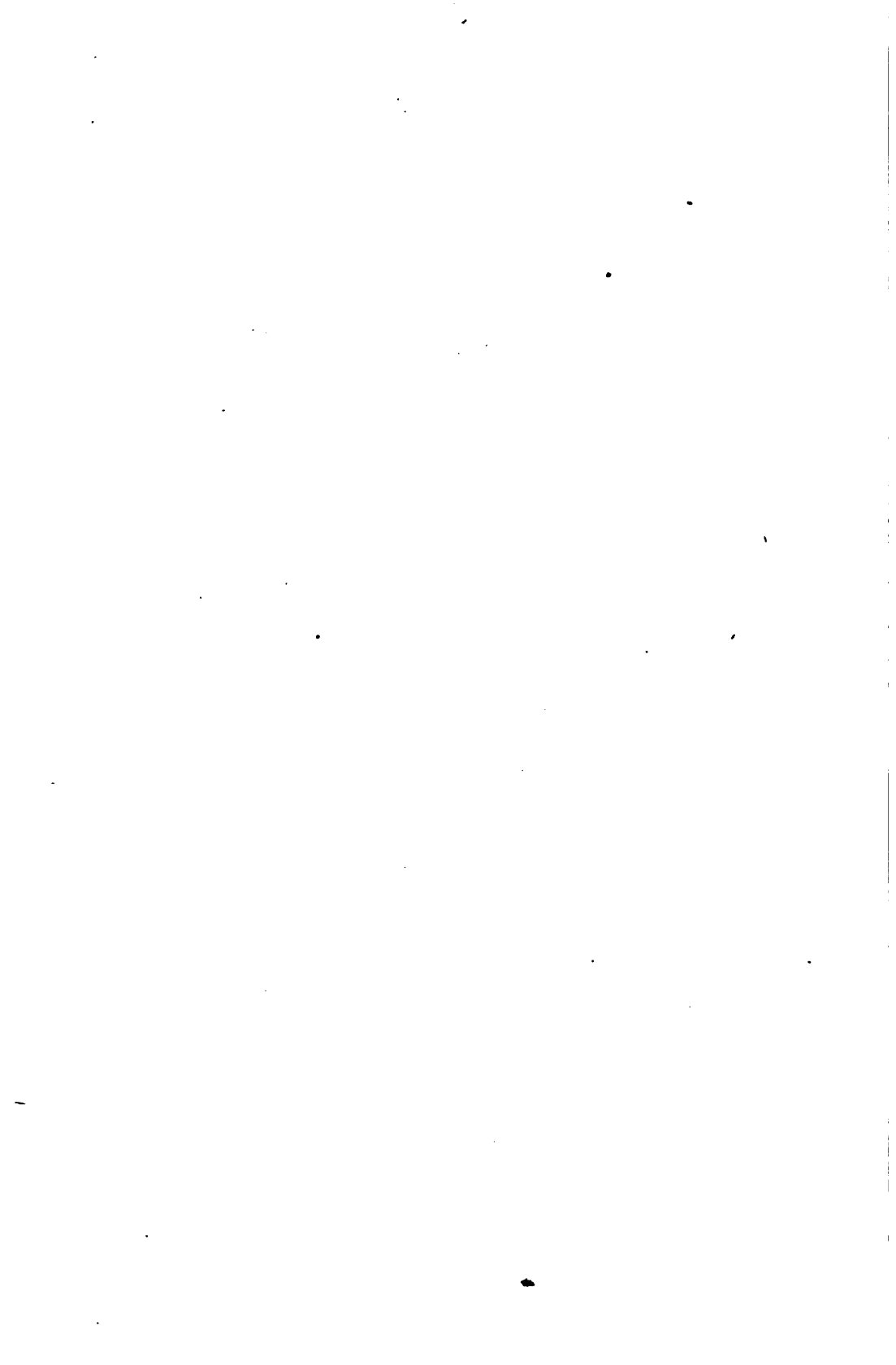
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August 7, 1905.





Pl. I.



Illustrating the use of Sewer Pipe in the Construction of Water Conduits.
(Plate loaned by the American Sewer Pipe Co.)

INDIANA.

DEPARTMENT

OF

Geology and
Natural Resources.

TWENTY-NINTH ANNUAL REPORT.

W. S. BLATCHLEY,

STATE GEOLOGIST.

1904

INDIANAPOLIS:

WM. B. BURFORD, CONTRACTOR FOR STATE PRINTING AND BINDING.

1905.

STATE OF INDIANA,
EXECUTIVE DEPARTMENT,
INDIANAPOLIS, March 7, 1905. }

Received by the Governor, examined and referred to the Auditor of State
for verification of the financial statement.

OFFICE OF AUDITOR OF STATE,
INDIANAPOLIS, March 7, 1905. }

The within report has been examined and found to contain no financial
statement.

D. E. SHERRICK,
Auditor of State.

March 28, 1905.

Returned by the Auditor of State, with above certificate, and trans-
mitted to Secretary of State for publication, upon the order of the Board of
Commissioners of Public Printing and Binding.

FRED L. GEMMER,
Private Secretary.

Filed in the office of the Secretary of State of the State of Indiana, March
28, 1905.

DANIEL E. STORMS,
Secretary of State.

Received the within report and delivered to the printer March 28, 1905.

THOS. J. CARTER,
Clerk Printing Bureau.

*State of Indiana,
Department of Geology and Natural Resources.*

INDIANAPOLIS, IND., March 7, 1905.

HON. J. FRANK HANLY, *Governor of Indiana:*

DEAR SIR—I have the honor to submit to you herewith the manuscript of the Twenty-ninth Annual Report of the Department of Geology and Natural Resources. The contents of the report pertain very largely to the economic resources of the State, and embody the results of the work accomplished by the different divisions of the Department during the calendar year 1904.

Yours, very truly,

W. S. BLATCHLEY,
State Geologist.

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B. A. KINNEY, MarionSupervisor of Natural Gas.
ALBERT STEVENS, Muncie.....Assistant Supervisor of Natural Gas.
ISADORE KESSLER, IndianapolisStenographer.

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DEPARTMENT OF GEOLOGY AND NATURAL RESOURCES.
INDIANAPOLIS, IND.

W. S. BLATCHLEY, State Geologist.

PLEASE ACKNOWLEDGE RECEIPT OF THIS VOLUME.

**In return, Scientific Books, Fossils, etc., and Implements of the Stone Age
are acceptable.**

State Museum, Room 126, Third Floor, State House.
**Open to the public from 8 A. M. to 5 P. M., except on Sundays and legal
holidays. Admission free.**

Office of State Geologist, Room 89, Third Floor, State House.

INTRODUCTORY.

The present volume is the twenty-ninth in the series of annual reports issued by the Department of Geology of the State of Indiana, and the tenth issued under the auspices of the writer. During the last decade the value of the natural resources produced in the State has gradually and steadily increased. While not including among their number any of the precious or even useful metals, they are, nevertheless, as varied in character and as valuable as those possessed by any State in the Union.

The following table will make plainer than any words the great increase in value of the six leading resources of the State during the ten years—1895 to 1904, inclusive—in which the writer has had the honor of being Director of the Department of Geology and Natural Resources:

	1895.		1904.	
	Output.	Value.	Output.	Value.
Coal.....	4,312,084 tons.	\$3,923,996	9,872,404 tons.	\$10,366,024
Petroleum.....	4,386,132 barrels.	2,807,124	11,331,340 barrels.	12,176,880
Natural gas.....		5,203,200		3,027,106
Building stone.....		1,718,976		3,081,925
Clay products.....		3,117,520		6,086,424
Portland cement.....			1,354,906 barrels.	1,341,396
Totals.....		\$16,770,816		\$36,028,755

The increase in value of the six resources for the ten years was \$19,257,939, or 115 per cent. When to the value of those mentioned there be added that of the hydraulic cement, lime, whetstones and grindstones, sand and lime brick, artificial stone, molding and glass sands, and other minor natural resources, the total will easily foot up forty or more millions of dollars. In a State which, a quarter of a century ago, was noted mainly for her crops of corn and wheat, her droves of fine cattle and hogs, her bluegrass pastures and her native timber lands, these figures

show a development of natural resources which is little short of marvelous.

The greater part of the present report is devoted to the "Clays and Clay Industries of Indiana." A dozen years ago the term "shale" was unknown among the natural resources of the State. Those great beds of soft, blue-gray, thin-layered rock, which occur over vast areas in the coal-bearing counties, were looked upon as a wholly valueless nuisance, which had to be removed or tunneled through before the underlying veins of coal could be reached. Today the smoke is pouring forth from hundreds of kilns where these shales are being burned into sewer pipe, hollow block, conduits, paving brick, pressed front and ordinary brick, drain tile, etc.

Not only have the Carboniferous shales been proven in the highest degree suitable for the best of such wares, but the Knobstone shales, which were accounted even more valueless than those of the Carboniferous Age, are in several places now being utilized for vitrified, pressed front and ordinary brick, and, in two of the largest factories of the State, as the clay ingredient of Portland cement. These Knobstone shales lie on or close to the surface over an area three to thirty-eight miles in width, extending in a southeasterly direction from Jasper County to the Ohio River. The factories now utilizing them are but the pioneers or forerunners of many yet to be; for these hitherto ignored Knob shales possess almost unlimited possibilities of service for practical use.

In the first part of the paper here presented, the location, thickness and area of the more available and valuable clay deposits of the State are given in detail and their possible use or fitness for certain wares indicated. In the second part a brief description is given of the methods of manufacture of the more important classes of clay products now made in the State, followed by a short mention of the larger factories making such products. Full tables of statistics have also been compiled which show the relative importance of the different classes of clay products manufactured. From these tables the following general table has been condensed, which gives the more important figures relating to the seven great general groups of clay wares produced in Indiana.

Statistics of the Clay Industry in Indiana for the Year 1904.

	Capital Invested.	Value of Output.	No. of Hands Em- ployed.
Ordinary brick and drain tile industry.....	\$2,923,653	\$2,748,733	4,171
Paving brick industry.....	504,000	545,721	465
Dry pressed brick industry.....	546,000	240,870	222
Refractory clay industries.....	306,750	271,760	228
Sewer pipe and hollowware industries.....	1,028,000	969,760	917
Pottery and allied industries.....	811,000	833,780	784
Encaustic tile and terra cotta industry.....	400,000	485,000	587
Totals.....	\$6,519,403	\$6,085,424	7,374

The second paper in the volume is the report of the State Mine Inspector James Epperson, of Linton, for the year 1904. Mr. Epperson and his two deputies have given careful attention to the duties which they are empowered to perform, and have tried to enforce impartially all laws relating to the mining industry. In his report the statistics of the Coal Industry for the year are given, the tables being very full and complete in detail.

The law gives the State Inspector power to examine only those mines which work ten or more men. It is my opinion that the law should be so changed as to require the examination, at least once each year, of every mine operating in the State, regardless of the number of men employed. Many mines employ from six to eight men, and the aggregate amounts to a large number. The life of any one of these men is as valuable as that of a man working in a larger mine, yet under the present law they receive no protection whatever. The air where they work is often extremely foul, man-shafts are more often lacking than present, and too little attention is given to the condition of the roof. Some of these abuses could at least be ameliorated by the occasional visit of an Inspector invested with power to better the conditions where possible.

From the report of Mr. Epperson the following table, showing the relative rank of the fourteen coal producing counties of the State, with the output of each in tons, has been prepared:

*Tons of Coal Produced and Wages Paid to Miners in Indiana in 1904,
by Counties.*

<i>County.</i>	<i>Tons Produced.</i>	<i>Wages Paid.</i>
Greene	2,307,964	\$1,984,305
Vigo	1,719,021	1,491,498
Sullivan	1,589,974	1,437,747
Vermillion	1,131,750	931,049
Clay	532,736	1,144,986
Parke	502,612	993,317
Pike	349,133	298,108
Warrick	341,900	212,419
Vanderburgh	237,625	234,911
Knox	150,567	132,133
Daviess	133,270	146,498
Gibson	85,595	90,082
Fountain	55,910	60,392
Perry	7,275	7,959
Total	9,872,404	\$9,165,404

Of the coal produced, 727,072 tons were block coal and the remainder bituminous. The total production for the year fell off slightly, that for 1903 having been 9,992,553 tons. The loss was due to over-production in 1903, when a large number of new bituminous mines were opened, and to a decrease in the output of block coal, a number of mines of which have been worked out. This coal is produced only in Clay and Parke counties, the former producing 387,307 tons, and Parke County the remainder, or 339,765 tons. The output of block coal in the two counties in 1903 was, respectively, 586,381 and 439,559 tons.

The report of the State Gas Supervisor, B. A. Kinney, of Marion, follows that of the Mine Inspector. On account of the numerous bores put down in gas territory in search of oil, Mr. Kinney and his assistant were kept busy in enforcing the law against the waste of gas, and the number of prosecutions against oil operators was greater than in 1903. His report shows that new wells of small capacity which, five years ago would have been considered worthless and been plugged, are now regarded as good, and every precaution is taken to preserve and prolong their life. The most of the bores sunk for gas had an output of less than 500,000 cubic feet daily, whereas a well producing less than 5,000,000 cubic feet was formerly regarded as of small size. The only new gas territory opened up in the main field during the

year was a small area in Grant County. Several wells sunk for oil in the vicinity of Princeton, Gibson County, developed a flow of gas varying from 400,000 to 800,000 cubic feet. The gas comes from the Huron sandstone, and it is very doubtful whether the supply will ever show much of an increase.

Almost all the gas produced in the State is now sold by meter measurement. Under this system the producer receives about five times as much per thousand for his gas as under the old flat rate system everywhere in vogue during the palmy days from 1887 to 1900. As a consequence, while the production has fallen off very greatly, the total value still represents a considerable amount.

Many inquiries having been received at this office relative to the plan outlined by the writer for the "Utilization of Convict Labor for Making Road Material," a paper has been prepared under that title, which embodies briefly the chief features of the plan. This paper, together with the copy of a bill bearing on the subject, which was introduced in the Sixty-third (1903) General Assembly, are submitted as a part of this report.

The production of petroleum in Indiana still continues to increase, the output for 1904 having been 11,331,340 barrels, valued at \$12,176,880. Petroleum, therefore, easily ranks as the leading natural resource of the State. The finding of oil in a deeper layer of the Trenton limestone was the principal feature of the industry for the year. This discovery alone kept up the production to that of 1903, as the initial output of new wells in the older portions of the field was nearly everywhere less than in that year. The price gradually fell during the year 1904 from \$1.31 to 95 cents, whereas the year before it had gradually risen. Several thousand new bores are necessary each year to keep the total output from falling off, and these are possible only when the market price is such as to stimulate the producer and guarantee him a fair profit on his capital invested. That the yearly output depends upon the price, and not upon the capacity of the field, is shown by the fact that the years 1897 and 1898 were the only ones since the striking of oil in the State, in which the production fell off, and during those years the price was low, ranging only between forty and sixty cents per barrel.

Natural gas is but the volatile part of crude petroleum which,

during ages past has risen into the higher porous portions of the Trenton rock. The presence of such a vast volume of gas as was extracted from the Trenton limestone of Indiana, between the years 1887 and 1900, is sufficient to denote the presence of an enormous body of the heavier petroleum or mother liquid. If the price is maintained at a fair figure, there is little doubt, therefore, but that the output of petroleum will hold its own, if not increase, for several years. It must ever be remembered, however, that with petroleum, as formerly with natural gas, we are drawing upon a stored product which is not being increased a single barrel, and that, therefore, the end of the supply is sure to come. In a paper entitled "The Petroleum Industry in Indiana in 1904" will be found the principal facts and statistics relating to the industry for the year.

In accordance with the usual custom, the report is ended with a paper on natural history, the one for the present volume, entitled "Insect Galls of Indiana," having been prepared by Dr. Mel. T. Cook, for a number of years Professor of Biology in DePauw University. In it Professor Cook describes and illustrates the more important excrescences or galls which occur so numerous upon the various wild and cultivated plants of the State. The paper is, therefore, of both economic and scientific value, and will doubtless prove of interest to many young observers in the State.

In addition to the field work, the results of which have been incorporated in the reports for 1903 and 1904, much progress has been made during the summer seasons of those two years in gathering data for a report on the "Road-making Materials of Indiana." Prof. J. A. Price spent one season and Prof. L. C. Ward two in this work and the results have been put in form for publication. It is the intention, if possible, to complete the field work in 1905 and to make the paper on road materials the principal feature of the report of the Department for that year.

THE CLAYS AND CLAY INDUSTRIES OF INDIANA.

BY W. S. BLATCHLEY.

SECTION I. CLAYS IN GENERAL.

INTRODUCTORY—DEFINITION OF CLAY—ORIGIN OF CLAYS—VARIETIES OF CLAYS—THE PHYSICAL PROPERTIES OF CLAYS—THE CHEMICAL PROPERTIES OF CLAYS—USES OF CLAYS.

No mineral resource of the earth has been longer used or has been made into such varied products for the benefit of the human race as clay. Found in all countries, easily obtained and, when moistened, readily molded into any shape which the fancy can invent, it is no wonder that prehistoric man, emerging slowly from that animal stage in which, for thousands of centuries he had existed, made early use of it. To his undeveloped mind no better form of amusement probably presented itself than that of dabbling in mud and molding it into fantastic shapes; just as, on the borders of many a pond or stream, "mud pies" are made by the youthful progeny of the twentieth century. Some of his rude products—sun dried—became permanent, were used by him as drinking vessels, and so begat in his crude mind an impression of their usefulness. He began to fashion them, not for amusement but for use, and the clay industry of the world had begun. From such a beginning, into what enormous proportions has it grown!

Clay products, when properly made and cared for, are among the most lasting works of man. Wind or rain, frost or fire, has little effect upon them. The most ancient remains of man's industry are the pieces of pottery vessels picked up on the sites of his former habitations, or removed from his burial mounds. The oldest buildings on earth are those made of sun-dried brick. From these rude vessels, relics of man's first handiwork, to the delicate and costly china-ware of our shops—from the adobe walls

on the plains of Persia and Mexico to the magnificent fronts of pressed brick and terra cotta of our present cities—what steps of human progress—what proofs of man's advancement in the art of clay working!

During the past ten years, the clay industries of Indiana have had a steady growth. The ever increasing demand for clay products for structural and road uses has been the chief incentive to this growth. The rapid advancement in the price of lumber, due to the disappearance of the forests of the State, has, in recent years, led architects and builders to investigate more carefully than ever before the advantages of clay products for structural purposes. Those investigations have, for the most part, proven satisfactory, and have shown the unexcelled fitness of such products for many uses to which stone, wood or other materials were previously put.

As a proof that the general public is beginning to appreciate this fitness, one has but to note the rapidly increasing use of terra cotta and pressed brick for the fronts of business blocks and the more fashionable and costly private residences; of hollow brick for their partition walls; of flue linings for their chimneys; of clay shingles for their roofs, and of encaustic tiles for their floors and mantels. Indeed, all present signs point to clay—that most widely distributed and cheapest resource known on earth—as the leading factor in the future structures built by man.

Nor has the increasing demand for clay products been confined to those used for building purposes. The use of vitrified products, such as sewer pipe, conduits and paving brick; and the refractory clay wares, such as fire brick and furnace linings, has also been constantly growing. Meanwhile almost daily inquiries for literature relative to the clays of the State have been received at the office of the Department of Geology. To partially meet this demand for literature the writer, in 1895, made a rapid reconnaissance of the clay deposits of the western and southwestern portions of the State, and a paper concerning them was published in the Annual Report of the Department for that year.* In that paper it was shown that with the exception of some of the clays

*"A Preliminary Report on the Clays and Clay Industries of the Coal-bearing Counties of Indiana."—In the Twentieth Annual Report of the Department of Geology and Natural Resources of Indiana, 1895, pp. 23-185 (1896).

used in making the better grades of terra cotta, encaustic tile and china ware, Indiana has, within her coal-bearing counties, the raw material in abundance for making every kind of clay product used within her borders.

Some of the best clay deposits and the largest clay factories of the State are, however, located in the northwestern counties, and in 1897, a second paper was prepared on the clays of that region,* in which it was shown that large deposits of clays suitable for terra cotta lumber and fine grades of pressed front brick were abundant in that section of Indiana. As a result of the advertising given the clay resources of the State in those two papers, the capital invested in the manufacture of clay products has more than doubled in Indiana since 1897. New industries have sprung up in many portions of the State and new discoveries have been made concerning the practical uses of large deposits of clay, before considered worthless. Moreover, three new railways which have been, or are now being built, have made available many new deposits not mentioned in either of the former papers. The edition of both reports containing those papers has been wholly exhausted for two or more years. It has, therefore, been thought best to prepare a new report on the Clays and Clay Industries which shall embrace the whole State, and the field season of 1904 has been devoted almost wholly to the gathering of the data for such report. The present paper is, therefore, based on this newly gathered data, combined with the more important portions of the two former papers, after bringing up to date the information therein contained.

DEFINITION OF CLAY.

It is rather difficult to give an accurate popular definition of the term "clay," as commonly used. In general the name is applied to any soft, earthy substance which, when finely ground and mixed with water, can be readily fashioned into any desired shape, which shape it will retain while being dried and burned. All clays, however, are not soft. Many of the best clay deposits of the State are hard, rock-like substances, which must be blasted

*"The Clays and Clay Industries of Northwestern Indiana."—In the Twenty-second Annual Report of the Department of Geology and Natural Resources of Indiana, 1897, pp 65-153 (1898).

and ground into powder before being used. Such clays are either "shales" or "under-clays."

A microscopic examination of clay shows that it is made up of a great number of small mineral fragments of many different kinds and of varying shape, ranging in size from those which are under 1-1000 mm. in diameter (known as clay) up to grains of sand which are sufficiently large to be easily visible to the naked eye. The smaller particles predominate, and when burned soften under the action of heat and then recombine when cooled to form the hard, rock-like ware or clay product.

According to the chemist, pure clay is a "hydrated silicate of alumina," the formula of which is $\text{Al}_2\text{O}_3 \cdot 2\text{SiO}_2 \cdot 2\text{H}_2\text{O}$, or $\text{Al}_2\text{Si}_2\text{O}_7 \cdot 2\text{H}_2\text{O}$. This simply means that two atoms of the element* aluminum, two of silicon and seven of oxygen are united into a molecule of the compound "silicate of alumina," and that that molecule is combined with two molecules of water, to form the clay. Pure clay, with the above composition, is called *kaolin*, its percentage composition being as follows:

Silica (SiO_2)	46.3.
Alumina (Al_2O_3)	39.8
Water (H_2O)	13.9

Most clays are, however, impure and contain numerous other compounds mixed with their kaolinite. The kaolinite, called the "clay base," is present in all materials to which the term clay rightfully belongs. The purer the clay, the greater the amount of kaolinite which it contains.

Many inquiries are made concerning "aluminum clay." From the above it will be seen that all clays contain aluminum in greater or less quantities. All clays are, therefore, aluminum clays. The metal aluminum is not, however, separated from a clay, but from a compound called "bauxite," which differs from

* For those who have little or no knowledge of chemistry I have thought it best to give here a definition of the word "element", as it will be hereafter used on numerous occasions. An *element* is one of the seventy primary forms of matter which make up the universe. It is a substance which has never been separated into anything simpler. Two or more elements united together form a *compound*. There are millions of compounds, but only seventy elements. For example: Wood is a compound, which in the chemical laboratory can be separated into three substances, carbon, hydrogen and oxygen, but no man has as yet been able to separate carbon, hydrogen or oxygen into anything simpler than themselves. Hence they are elements. The seventy elements bear the same relation to the compounds as the twenty-six letters of the English language bear to its four hundred thousand words. Or, to state it differently, the elements form the alphabet of the universe.

a pure clay in that its aluminum is combined with oxygen to form a soluble oxide instead of with silicon and oxygen to form an insoluble silicate. Bauxite occurs in Alabama, Arkansas and other southern states, but not in Indiana.

ORIGIN OF CLAYS.

The clay base or kaolin in all clays had its origin in the decomposition of granite or other primitive rocks which contained feldspar. By primitive rocks we mean those which formed the first crust of the earth and were largely or wholly igneous in their nature, i. e., they were rocks which had been acted upon by great heat, and had not been deposited in stratified layers by water. Granite is an example of such rocks and is composed of three minerals: quartz, mica and feldspar. Quartz or silica is wholly insoluble in rain water or ordinary acids. Mica is also as insoluble as quartz. The feldspar of granite is composed of a silicate of potash, which is soluble, combined with a silicate of alumina, which is insoluble, and this combination acts as a cement. Granite, then, may be regarded as composed of particles of insoluble quartz, united to particles of insoluble mica by a cement called feldspar, which is partially soluble and partially insoluble.

When the granite of the first crust of the earth was exposed for centuries to the air and water, the oxygen of the former and the carbonic and other acids in the latter, acted in time upon the feldspar or cement. As the water percolated through the granite, which had been softened by long exposure to the air, the carbonic acid united with the potash of the feldspar to form a carbonate of potash very soluble in water. The feldspar or cement was thus destroyed and the granite crumbled. From it resulted a mass of kaolin (the insoluble silicate of alumina of the feldspar) mixed with quartz particles or sand and numerous scales of mica. This resulting kaolin now forms the clay-base, or essential part of all clays. Besides granite, syenite, gneiss and other primitive rocks contained much feldspar, and by a similar decomposition as that noted have yielded their proportion of kaolin. The latter is, therefore, simply one of the kinds of matter resulting from the decay of feldspathic rocks.

VARIETIES OF CLAYS.

The clay materials resulting from the decay of feldspar may be broadly classified into two great groups—*residual* clays and *sedimentary* clays.

RESIDUAL CLAYS.—When a mass of feldspathic rock weathers down to clay and the latter remains at or close to the place of its origin, the deposit is termed a *residual* one, since the clay thus formed represents the residuum of the rock decay, the soluble portions of the parent rock having been wholly or partly carried off. If the parent rocks contained much feldspar or but little mica, and were covered before their decay by some porous material such as conglomerate sandstone through which the water could easily pass, large beds of comparatively pure kaolin were formed. Such deposits are called residual rock kaolins and are among the richest and purest clays known to man. The kaolin deposits of Lawrence and Martin counties, Indiana, are secondary residual clays; i. e., sedimentary clays which have undergone metamorphosis, probably by heat, and have thereby been changed into kaolin.

Surface residual clays are usually very impure and highly colored by iron, and since they are formed by weathering they often show a gradual passage from the fully formed clay at the surface to the parent rock below. In limestone residuals, however, the change from clay to rock is quite sudden. Over the greater part of the driftless area of southern Indiana there occurs a surface clay which is thus residual, being derived from the decay of the underlying limestone or sandstone rocks. During thousands of years the rainfall penetrating these rocks has carried with it well known solvent agencies derived from the atmosphere and from the vegetation on the surface. Attacking the rocks, these solvents have borne away the several ingredients which they were competent to dissolve and have left the rest behind. The result has been the production of well disintegrated earth or soil at the surface, merging into clay and partly decomposed rock below. The clayey portion is composed mainly of a mixture of kaolinite, oxides of iron, and sand combined in varied proportions, the kaolinite being the silicate of alumina which was disseminated in small particles through the limestones or sand-

stones at the time of their formation. This residual surface clay is, in general, free from those minute angular fragments of foreign rocks which occur so commonly in most glacial or drift clays. It is never stratified like the latter sometimes are, and its texture is more homogeneous or alike throughout. For these reasons its quality for manufacturing purposes is often much superior to that of most of the surface drift clays of northern Indiana.

SEDIMENTARY CLAYS.—When the clay has been carried by water, ice or other agency from the place where first formed to a new location, and redeposited in water, it is called a *sedimentary* clay. Ninety per cent. of the clays of Indiana belong to this group. Gentle rains and earth-born torrents, little trickling rills and strong streams are ever at work, tearing down the clays from every slope where feldspathic rocks have decayed and bearing them away to lower levels. While being carried onward, the clay-base or kaolin, comparatively pure at starting, becomes mingled with many impurities, such as the remains of decayed limestones, oxides of iron, etc. It, as well as these impurities, are at the same time washed and ground fine by the action of the flowing water, until finally the entire mixture is deposited as a bed of fine sedimentary clay at the bottom of river, lake or sea, perhaps one, perhaps a thousand miles from the home of its mother rock. Since the first rainfall upon the primitive crust of the earth this process of disintegration and transportation of clay by water has been going on, and on it will continue until the end of time, for the forces of nature are never ceasing in their action.

As a result, vast beds of sedimentary clays are found wherever rivers, lakes or seas have at some former period covered a portion of the surface of the earth. The sedimentary clays of Indiana may be classified as follows:

1. **SHALES.**—A shale is only a clay which has become consolidated into a hard mass by pressure. When weathered or when ground and mixed with water, it becomes a soft plastic mass like clay. The materials composing the shales of Indiana were, many centuries ago, deposited in the form of a fine aluminous sediment upon the bottoms of the seas, which then covered the area now occupied by the present State. After these beds of clayey sedi-

ment were laid down in the sea, thick beds of other kinds of sediment were deposited over them, and by the weight of those overlying beds the clayey sediment was pressed and consolidated into the hard, stone-like mass called "shale."* The chemist recognizes no difference between a shale and a clay, and the geologist distinguishes them only by a thin lamination, or capability of being separated into layers, which is present in the shale and absent in the clay, and which is due to the former having been deposited intermittently in deep, still water. When quarried or exposed, the shale splits into thin laminæ along the lines or planes of stratification.

In the coal bearing areas of the State, shale is often erroneously called "*slate*." True slate does not occur in Indiana. It is a rock which has been formed from shale under the action of both heat and pressure. These two agents have destroyed the original layers of stratification so that the slate no longer splits along them, but on the other hand a new direction of splitting has been produced, parallel to which it splits evenly and regularly. Moreover, if true slate be ground fine and mixed with water it will not form a pasty plastic mass like clay. Shales occur in those regions where the rocks lie flat or nearly so, while slate is found principally in mountainous regions where the rocks have been disturbed, tilted and folded.

Two great groups of shales of economic importance occur in Indiana, viz., the Carboniferous shales of the Coal Measures and the Knobstone or Waverly shales of the Lower Carboniferous era. They constitute the most valuable sedimentary clay deposits of the State and will be treated more fully in a later section.

2. UNDER-CLAYS OR "FIRE-CLAYS."—In the coal-bearing counties of Indiana shales usually overlie the veins of coal, while underlying each coal seam is almost always a bed of "fire-clay," a form of sedimentary clay usually richer in kaolinite and silica than the shales. This under-clay had its origin in the same manner as did the shales, but its freedom from lamination is a proof that it was deposited in shallower water. Its relation to the overlying coal seam plainly shows that it once formed the soil which supported that luxuriant plant growth which was after-

*That pressure alone will consolidate clay particles is shown by the ease with which firm brick are molded by machines by the dry clay process.

ward changed into coal. Those plants removed from that soil many of the elements now found in shales and clays, and as a result articles made from under-clays are more refractory, i. e., will withstand far greater heat without melting, than will those made from shales or ordinary soft clays. However, but few of the under-clays of Indiana are, properly speaking, refractory clays of a high grade. The majority of them contain so great a percentage of potash, lime, soda and other fluxes that they fuse readily at even moderate temperatures.

Sandstone and shales are not infrequent under the coal, especially the former, and all intermediate grades are found, from a pure fire-clay through sandy fire-clay to what is practically sandstone. That this sandstone takes the place of the under-clay is shown by the presence of the plant stems penetrating it. This underlying sandstone, when very fine grained, is commonly known as "gannister," and in some places has been mined, ground, and used for the hearths of iron furnaces, for lining steel converters and similar purposes.

3. DRIFT CLAYS.—These are the most common and widely distributed clays of the State, being found everywhere over the drift covered area of its northern and central portions. From the shales and fire-clays above mentioned and which underlie them in the Coal Measures, they differ widely in the amount of lime and other foreign constituents which they contain. This difference is mainly due to the fact that they were transported to and deposited in their present resting places, not by water in the liquid form, as were the shales and fire-clays, but by a great glacier or moving sea of ice which, thousands of years ago, flowed slowly over the greater portion of our State, grooving and planing the surface of the solid rocks, strewing for hundreds of miles in its track beds of clay and sand and gravel—pushing before it the accumulated soils and clays of centuries, and mixing, transporting and changing them to such an extent as to well nigh destroy their separate characteristics and greatly increase the difficulty of their proper classification.

Transported and deposited as they were, these drift clays are, in general, too impure for any use but the making of ordinary brick and drain tile, and oftentimes they contain too many lime pebbles even for this purpose. This is due to the grinding up and

mixing with the clays much of the surface limestones over which the glacier passed, as the erosion of that epoch not only removed and commingled the previously formed residual deposits, but planed away the country over a vast area to a greater depth than had been reached by any previous decay. These eroded limestones and the clays with which they were mixed were many of them ground into impalpable powder and deposited before a subsequent decay could take place, so that, as has been well said, "the drift clays are, many of them, rock flour and not, as are the residual clays, the products of rock rot."*

4. ALLUVIAL CLAYS.—Along the lowlands and terraces or second bottoms of the larger streams of Indiana are found, at intervals, very large deposits of alluvial clays. These are sedimentary clays of the present age. They owe their origin either to the deposition of fine particles of clay in the eddies of the streams, or to the slow accumulation of the clayey sediment during the annual overflows of the areas which they now occupy. In some places they are 30 to 90 feet in thickness and remarkably free from pebbles or coarse impurities of any kind. Oftentimes they alternate with strata of sand or even gravel. They are usually very plastic and are sometimes sufficiently fine grained to be employed in the manufacture of pottery. In Ohio and other states similar clays have been used for several years in the manufacture of paving material, but in Indiana, their only use, heretofore, has been in the making of ordinary building brick and drain tile.

5. SILTY OR MARLY CLAYS.—These clays resemble very closely those of the preceding class. They differ in that they were deposited in bays, lakes or harbors, in still water. Much "rock flour" containing a large percentage of kaolin was produced by the passing of the glaciers over beds of shale. This was held in suspension by the glacial streams and finally deposited in the bays and lakes of that epoch. These marly clays are, in general, composed of finer grains, and are more usually in thin layers, separated by a coating of sand, than are the alluvial clays. They contain a greater percentage of finely disseminated lime and magnesium carbonates, and for that reason products burned from them are usually cream colored or whitish. These clays, up to the

* Chamberlain, T. C.—Sixth Ann. Rep. U. S. Geol. Surv., p. 249.

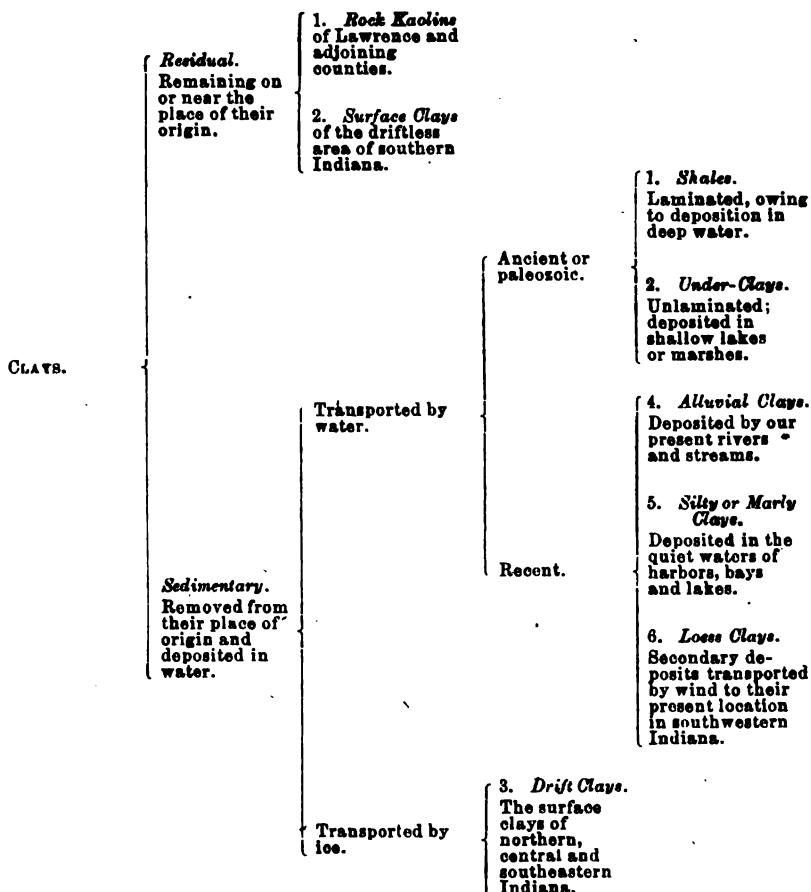
present, have been found to occur only in the northern third of the State, in areas formerly occupied by the southern extension of Lake Michigan, small fresh water lakes and bays or inlets of the larger streams.

6. **LOESS CLAYS.**—The surface of a large area in southwestern Indiana is covered with a very fine grained, clayey buff or brown silt, known as "common loess." It contains but a small percentage of lime, rarely effervescing with acid. Lime pebbles are very scarce, and where found are generally of small size. Other pebbles do not occur except where the sheet of loess is so thin that roots penetrate to the underlying drift and, on the felling of the tree, pull the pebbles up into the loess. It presents no evidence of stratification nor does it contain fossils of any kind. Being very uniform in composition, and free from foreign impurities, these common loess clays are much better suited for clay working purposes than the pebbly drift clays which in many places lie between them and the underlying Coal Measure rocks.

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The beds of sedimentary clay now found in Indiana are none of them identical with those first formed after the decay of the primitive crystalline rocks. That igneous force which somewhere is ever pushing the bottom of the sea upward, long ago raised the first shale beds into dry land. Rain and frost again caused their decay, and again did the agency of flowing water mix and grind and bear their particles to the bottoms of new seas and lakes. No one knows, or can ever know, how often these successive changes of elevation, disintegration, erosion and deposition have taken place in the ages past; but the clay base in the materials of our buildings and roadways of today would, if traced backward, lead us through many a geologic change to the granites and gneisses of the old archæan times.

Summing up the last few pages we find, therefore, that, based either upon the relation of their present location to their place of origin, or the manner of their transportation and deposition, we have the following classification of our Indiana clays:



THE PHYSICAL PROPERTIES OF CLAYS.

All clays suitable for manufacturing purposes possess certain essential and characteristic physical properties which will now be briefly considered.

SLAKING.—If a bed or mass of clay be freshly opened up or exposed to the air for any length of time it absorbs moisture and weathers or slakes to a finely divided mass. If it be a cliff of shale, the pieces will flake off and fall to the base where the fragments will divide and sub-divide until the whole mass is weathered into a soft plastic clay. If the shale comes close to the surface over a level or flat area the clay will be found on top, and as we pass downward a mixture of clay and partially slaked shale frag-

ments is encountered, which finally merges into the fresh un-slaked or unweathered shale. The power to slake readily is, therefore, a great advantage as it enables hard clay masses to be softened and comminuted and thus often does away with the necessity for elaborate grinding processes. In fact, nature will often produce a far more plastic mass by weathering than could be produced by grinding the fresh material. Clays which disintegrate rapidly can be mixed up readily and can be easily washed in case they have to be freed from impurities by mechanical means. Clays which are dense slake very slowly. Many shales will not slake when thrown into water, but exposed to the slow, disintegrating action of the weather they fall to pieces slowly but completely.

Clay manufacturers, especially those who make refractory products or pottery, often expose large quantities of clay to the weather for several months. By such weathering the hard clays are broken up into fine grains which greatly reduces the labor of grinding. The soft clays are rendered tough and plastic by their exposure. At the same time the oxygen of the air changes the sulphide of iron present in many clays to a sulphate, which is readily dissolved and carried away by rain water. Any sulphates of lime or magnesia present are also rendered soluble and are removed. These compounds of sulphur are all harmful and the weathering is, therefore, beneficial from a chemical as well as from a physical standpoint.

PLASTICITY.—The most important physical property of clay is plasticity. It is this property which causes clay, when mixed with water, to become a tough, pasty mass readily capable of being fashioned into any form by the hands or molds; and, when so fashioned, to retain its shape while being carried to the drying room or kiln. It is hard to realize what an important property this really is, for without it we could do but little with the material. If we take the white, non-plastic kaolin of Lawrence County, grind it to an impalpable powder and mix it with a certain amount of water, we shall have a mass just sufficiently coherent to ball together. If, however, we try to mold the wet mass into a form it quickly crumbles and shows itself quite unworkable. From this extreme up to the most plastic of potters' clays, which will respond to every touch of the artist's hand and preserve every line

of the graver's tool, we find among the clay materials of Indiana every grade of variation.

This property of plasticity is due to several causes, chief among which is the presence of water combined with the silicate of alumina in the formation of the clay. Clays, even when thoroughly dried in the sun and air so that they have every appearance of being dry powders, will sometimes contain as much as 12 or 14 per cent. of this combined water. When the clays are once burned and this combined water driven off by heat, they lose their plasticity. Brick dust or burned clay may be ground fine and moistened, but unless mixed with some unburned plastic material the particles will not cohere. The presence of a certain proportion of particles which actually soften and become sticky under the action of this combined water is probably the principal cause of the plasticity. These active particles which become coherent when wet are called *colloid* (which means glue-like), to distinguish them from the inactive, crystalline and amorphous grains which are also present in almost every clay.

An absence of crystals in the clay-base or kaolin thus adds greatly to the plasticity of the clay, as does also the fineness to which the grains of kaolin have been reduced. Clays which are mixed in autumn and "weathered"—i. e., exposed to rain and frost throughout the winter, have the crystalline structure of their kaolin more or less broken up by alternate freezing and thawing. Their degree of fineness is at the same time increased, rendering them more highly plastic and therefore more readily molded into any desired shape.

As noticed above, our Indiana clays vary from those in which the plasticity is low or wholly absent to those in which it is very strong. The former are said to be "lean," the latter "fat" or "strong." The sedimentary clays are much more plastic than the residual clays. The former in their journeyings have been ground and reground, their crystalline structure destroyed, and their particles reduced to a very fine condition and thus rendered more susceptible to cohesion with particles of water. It is true many of them may have been consolidated into shales and under-clays, but most of these, by repeated grindings, are again rendered plastic.

If a clay is lean its plasticity can be increased by the admixture

of a more plastic one; or, if, on the other hand, it is too fat, it can be tempered by the addition of sand. Sand is a powerful destroyer of plasticity, but it should also be borne in mind that the more sand that is added the greater will be the porosity of the product. Manufacturers of common brick unfortunately very often have a tendency to add too much sand to their clay, because it makes it so much easier to work.

AIR SHRINKAGE.—"This property refers to the decrease in size which takes place during the air drying of the clay, and is due to the evaporation of the water which has been used to mix up the material. The amount of air shrinkage usually stands in direct relation to the quantity of water absorbed by the clay during the mixing or tempering. Since plastic clays absorb more water than lean or slightly plastic ones, they show a higher air shrinkage. The air shrinkage ranges from one to two per cent. in very lean or sandy clays up to eight or ten per cent. or possibly even more in very plastic material. The air shrinkage is a matter of considerable importance to the clay worker, for the reason that the greater the decrease in size of the clay product during drying the greater the danger of its warping or cracking. Clays with a high air shrinkage usually have to be dried very slowly and carefully, and the aim of the manufacturer, therefore, is to find a clay or make a mixture of clays which will not only have a low air shrinkage, but which will also stand rapid drying. The air shrinkage begins as soon as the clay has been molded or is taken from the machine, and all the moisture is not driven off until the brick is placed in the kiln. The last portions of it evaporate in the early stages of burning, during which period great quantities of steam can be seen issuing from the chimneys of the kiln; this is known as the *water-smoking* process. Some clays part readily with the water contained in their pores, especially if they are sandy." *

FIRE SHRINKAGE.—"All clays undergo a second diminution in volume during the firing, and this may range from two or three per cent. up to 15 or 20 per cent. or even more, showing just as much variation as the air shrinkage, but being due to different causes. The fire shrinkage does not really begin until the chemically combined water and carbonic acid gas are driven out of the clay, consequently it commences at about dull redness. Although

* *Ries.*—Clays of the U. S. east of the Mississippi River, 1903, p. 20.

most clays shrink in burning, there are a few, such as those containing much quartz, which tend to expand at high temperatures. Both the air shrinkage and the fire shrinkage may often be decreased by the addition of sand to the clay mixture." *

INSOLUBILITY.—A fifth physical property of clay is insolubility. The better grades of clay are not affected by any acid or other chemical. On impure clays, however, especially those containing much lime, carbonate of iron or allied chemical, muriatic or sulphuric acid will cause an effervescence or bubbling, and the clay will be in part destroyed. This property of insolubility possessed by the raw clay is not lost in the burning, and the finished clay product can be brought in contact with acids or chemicals without being impaired. It thus enables these products to be put to many uses in which utter freedom from chemical action is demanded.

TENSILE STRENGTH.—It is this property which provides strength in the air-dried clay so that articles fashioned of it can be transported to the kiln without crumbling and breaking. In most clays this property seems to stand more or less in relation to plasticity—that is, very plastic clays often, but not always, have a high tensile strength. Such a strength in clay is desirable, since it helps the ware to resist cracking in drying, and also permits it to stand handling better in its air-dried condition. The kaolins show the lowest tensile strength of all the clays, while the impure Gumbo clays of the Central and Western States show perhaps the highest cohesive power of any known. The property is tested in the laboratory by molding briquettes of a special shape which, after drying out are pulled apart in a machine designed for the purpose. The strength of different kinds of clays, as determined in this manner, is given in the following table:

Tensile Strength of Clays.

	<i>Pounds per Sq. Inch.</i>
Pure kaolins	5-20
Common brick clays.....	30-100
Pottery clays	100-400
Ball clays and other very plastic clays.....	200-500

INFUSIBILITY.—Kaolin and many of the purer grades of fire-clay can be subjected, without fusing or melting, to the highest heat

* *Ries. Loc. cit.*

obtainable in the practice of metallurgy. This fire resisting or refractory property is one of the most remarkable and valuable which clays possess. Upon it depends their use for making that long list of materials which of necessity must be subjected to intense heat, such as crucibles, gas retorts, glass pots, reverberatory furnaces, etc.

But it is only the purer clays, as kaolin, or kaolin mixed with silica (the so-called fire-clays) that are infusible. When other substances commonly found in sedimentary clays, such as lime, potash, iron, etc., are present, a comparatively low temperature will bring about a fusion or melting. Chemical changes will result, and new compounds, chief among which are complex artificial silicates, will be formed. To all such substances whose presence tends to bring about the melting of refractory material the general name of "*fluxes*" is given. Named in the order of their power to cause the fusion of kaolin, the leading fluxes are potash, soda, iron, lime and magnesia. Good grades of fire-clays can not contain more than three to four per cent. of these fluxes. Most sedimentary clays contain a much higher per cent., and for this reason fire-bricks, furnace linings, crucibles, retorts, etc., can not be made from them.

The infusibility of kaolin is chiefly due to the same property being possessed by its constituents, silica and alumina. Each can be melted only in the flame of the oxy-hydrogen blow-pipe. Combined with kaolin to form the fire-clays is almost always a large per cent. of free silica or sand, which is nothing more than small particles of quartz. This is the only impurity which can be mixed with kaolin without lessening its property of infusibility. In all the better grades of fire-clays a large percentage of this free silica is present. The Montezuma fire-clay, which has a wide reputation throughout Indiana and adjoining states for fire-resisting qualities, contains a total of 83.4 per cent. of silica; while some refractory materials are manufactured from quartzose rock, which is finely ground and then mixed with a small amount of plastic fire-clay to give it tenacity. But few large deposits of either kaolin or fire-clay free from fluxing impurities are known to exist; and such of these as are readily accessible are of great commercial value.

Fine grained clays will, other things being equal, usually fuse at a lower temperature than coarse-grained ones. Common brick

clays will often fuse at a temperature of from 2,000° to 2,300° F. Stoneware clays can often be heated to a temperature of 2,600° or 2,700° F. before becoming viscous, while good fire-clays do not become viscous until 3,200° or 3,300° F., or even more, is reached.

"The temperature of fusion may be determined in several different ways. One method consists in using test pieces of known composition, and consequently known fusibility. Such a set, which is much used by practical clay workers, is known as Seger cones. They are made up of a series of mixtures of clay and fluxes so compounded and graded as to represent a succession of fusion points, each being but a few degrees higher than the preceding. The ingredients of these cones are kaolin, feldspar, quartz, marble and pure ferric oxide. The series consists of 58 members, the lowest one having a fusion point of 1,094° F. (590° C.), and the highest 3,362° F. (1,850° C.). In order to test the heat of a kiln, these cones are placed in the fire at a point where the flame will not strike them. As the heat rises the cones begin to soften, and when the fusing point is reached each bends over until its tip touches its base. The cones are placed in the kiln at a point where they can be watched through a peephole. Several cones of the several members are put in, for example, 05, 1 and 5. If cones 05 and 1 are melted in the burning, but 5 is not affected, it indicates that the temperature is between 1 and 5. In the next burning 2, 3 and 4 are put in; 2 and 3 may be fused but 4 remains unaffected, showing that the temperature of the kiln was the same as the fusing point of cone 3." *

INDURATION.—The next of the physical properties of clays to be here mentioned is that of *induration*. By this is meant the power which it possesses of hardening when subjected to heat. The importance of this property can scarcely be over-estimated. Without it an article fashioned from clay would be only so much stiff mud which, on exposure to rain or frost, would soon crumble to dust on account of its porosity and attraction for moisture.

The first change taking place in the clay when heated is the driving off of the water which has been added to it to make it soft and plastic. This should be done so slowly as to allow all of this moisture to escape as vapor before the clay becomes heated above the boiling point of water, for the generation of steam

* *Ries.*—Loc. cit. p. 23.

would, of course, tend to destroy the structure which has been imparted to the clay and which is important to keep. After this hygroscopic water has been driven off the heat may be increased more rapidly until, at about $1,000^{\circ}$ F., the ware will begin to shrink and lose weight on account of the loss of the combined water in the clay-base or kaolinite.

When the clay has been heated up to a temperature of redness or above, depending on the refractory quality of the material, a hardening of the mass takes place. This is due to a first softening of the particles under the action of the heat, the result of this being that they stick together and make the product, when cold, as "hard as a rock." It is this property of hardening under fire that makes clay products so resistant and durable.

All clays do not, however, act alike when heated. Some soften very rapidly when burned; others very slowly. Some soften at a very low temperature and are consequently said to be easily fusible; others do not soften until burned to a very high temperature and are called refractory. Fire-clays are refractory and brick clays are usually easily fusible.

When a piece of shale is put into a kiln or furnace and burned, the first signs of fusion are a softening of the particles. If the shales be now cooled, it will be a solid mass, and hard enough to cause difficulty in scratching it with a knife. It has been heated to a condition of *incipient fusion*, or the point at which the particles become soft in the fire. Common bricks and earthenware are baked only to this first point, and retain an open and porous structure, the bond of incipient fusion being sufficient to form the clay into tough, stone-like materials.

If the same piece of shale is heated still higher, the particles soften so much that they are able to adjust themselves better and to pack to a dense, impervious mass, and when cool the individual grains will no longer be recognizable. This is the condition of *vitrification*, and all stoneware, paving brick and sewer pipe makers try to vitrify their wares.

If the piece of shale is once more put into the fire and heated to a higher temperature than before, the clay will finally become so soft as to cause the mass to run or become viscous. This is known as the condition of *viscosity*.

The difference in temperature between the points of incipient

fusion and viscosity varies in different clays. In calcareous clays the softening action takes place rapidly and the two extremes may not be more than 50° or 100° F. apart, but in non-calcareous clays the point of incipient infusion and vitrification may be separated by an interval of 400° F. Though the above named three stages in the burning of the clay are recognized, it is sometimes rather difficult to determine them exactly.

The practical bearing of all this is that, in burning a kiln of ware to vitrification, it is impossible to bring the temperature just up to that point and then stop it; on the contrary, the heat is apt to go a little beyond that before it can be stopped. If the shale passes rapidly from the condition of vitrification to viscosity, then there is danger of melting the contents of the kiln in attempting to vitrify them. But if the two points mentioned are some distance apart, then there is not so much danger in slightly overstepping the point of vitrification.

To safely vitrify a clay, the points of vitrification and viscosity should be at least 125° F. apart, and preferably 200°. *In clays containing a high percentage of lime, they are not over 50° apart, and hence such clays are not adapted to making vitrified wares.*

COLOR.—The color of a clay before it is burned is of little importance except in so far as it serves to indicate the presence of iron, which is one of the fluxing constituents. Many clays are so brilliantly colored with iron—for example the residual clays of the southern or driftless area of Indiana—that the color at once indicates their non-refractory character. In the kiln, however, except in perfectly white clays which burn white, color changes invariably take place. Many black clays stained by organic matter burn white, while others burn to reds, buffs and cream colors. Shales with only 2 to 3 per cent. iron oxide burn buff, while those with 4 or more per cent. burn red. A buff or cream color is also produced if the clay contains much carbonate of lime, say three times as much lime as iron, and this is what causes many of the northern Indiana brick clays to burn a cream color.

Magnesia exerts the same coloring effect on the burned ware as lime, and alkalis tend to turn the iron red into a brown. Silica has no effect on the color in burning. Nothing of importance has ever been accomplished technically in causing a dark burning clay to burn white.

CHEMICAL PROPERTIES OF CLAYS.

A chemical analysis of a pure clay would show but three ingredients present, viz., silica, alumina and combined water. These, as already noted, make up the kaolinite or clay base. Pure deposits of kaolin are, however, very rare, as almost all clays, and especially all sedimentary ones, contain other ingredients which they have gathered in their wanderings from the spot where the kaolinite was first freed from the mother rock. Anything other than the clay-base may be considered an impurity. The impurities most commonly found in clays are silica or sand, compounds of iron, lime, magnesia, potash, soda, and sometimes organic matter. The uses to which any clay can be put are determined very largely by the impurities which it contains. Some influence the color, others the shrinkage, while all exert more or less effect on the fusibility of the material, the influences in each case increasing usually with the amount of the impurity which the shale contains.

The practical clay worker usually considers a physical test far more valuable than a chemical analysis, for the reason that the facts contained in the former are easily capable of interpretation, while those of the latter can not, as a rule, be utilized by him. Moreover, clays of widely different properties will sometimes have almost identical chemical composition and vice versa. Combined with other data the results of complete chemical analysis are, however, always of value, as from them any one with experience can judge accurately as to the refractoriness or fusibility of a clay.

SILICA.—Taking up the so-called impurities of clays in the order above mentioned, we find that the most common is silica or sand other than that in the clay-base. This occurs either free as quartz particles, or in a combination with the other impurities in the form of silicates. The free quartz particles, commonly known as sand, are found in all clays, and though classed as an impurity, they are in most instances a necessary constituent, since their presence prevents that warping, shrinking and cracking while drying, which is sure to take place in the made-up ware when too great a percentage of pure kaolin is present. Clays which are tough and exceedingly plastic are termed “fat clays,” and to them sand is often added artificially to lessen the plasticity

and render their products more easily dried. Uncombined silica in moderate quantities is thus beneficial, since it preserves the form at high temperatures. When in excess it destroys cohesion and renders the ware porous, brittle and weak.

COMPOUNDS OF IRON.—Next to sand, compounds of iron are the most common and the most important impurities of clays. Pure iron does not exist free in nature, but its compounds are very abundant. Among those occurring *uncombined* in clays are the two oxides—the proto or ferrous oxide (FeO), and the per, sesqui or ferric oxide (Fe_2O_3); also the carbonate (FeCO_3); the sulphide (FeS_2), and the sulphate (FeSO_4). In addition to these many chemists believe that most every clay has, *chemically combined* with its kaolin or clay-base, a hydrated per-oxide of iron ($2\text{Fe}_2\text{O}_3 + 3\text{H}_2\text{O}$), the two together forming a complex double salt of iron and alumina.

The two *oxides* occur in greater or less quantities in all Indiana clays and serve both as coloring agents and as fluxes. They have much to do with the colors of clays, both in the raw and burned state, for iron is one of the great coloring agents in nature. Compounds of iron cause the green color of grass and leaves, the bright red color of the blood of animals, and the darker red of some soils, clays and sandstones. Ferrous oxide, the more common of the two, is found in all drift and alluvial clays, especially those of a bluish or greenish-blue color. When such clays are burned the ferrous oxide is changed to a ferric oxide, which is brownish red, and the wares become the same color.

Experience, time and again, has proven that no one can tell by looking at a clay, or even by analyzing it, what color will be produced in it by heat. In general, however, it may be stated that the finer the particles of these oxides are, and the more evenly they are disseminated through the clay, the more uniform and certain will be the color. For this reason chemists believe that the complex double salt of iron and alumina, mentioned above, has much to do with the ultimate color of burned clays as, of necessity, the iron oxide in this is more thoroughly and evenly distributed throughout the raw material. If the oxides occur *free* in small grains or nodules, a chemical change will be caused in them by heat, and they will be apt to form black specks, scattered irregu-

larly through the body of the ware instead of coloring it evenly throughout.

The color to which a clay burns is, moreover, determined to a large extent by the kind of heat to which it is subjected in the kilns. When a clay fairly rich in iron is exposed to an *oxidizing* fire in burning, the iron invariably tends to color the material red, and the depth of this color increases with the amount of iron present. If, however, the clay is exposed to a *reducing* action in burning, which is the case when an insufficient quantity of air enters the kiln, then the color, instead of being red will be a bluish black. The same color is also produced if even in an oxidizing fire the clay is carried to a condition of viscosity, in which state a disassociation of the iron compound takes place, the ferric oxide being reduced to the ferrous condition. The amount of ferric oxide permissible or desirable in a clay depends upon the use to which it is to be put. Thus kaolins, which are to be utilized for making china, should have under one per cent., if possible, while brick shales or pottery clays, on the other hand, should have four or five per cent. of the same material in order to produce the good red coloration.

Besides imparting a color to clay products, the oxides of iron act as fluxes. Especially is this true where from 5 to 15 per cent. of these oxides are present, as in many of the shales and drift clays. Such clays fuse at much lower temperatures than others which are similar in every respect, except in the percentage of iron oxides.

Pyrites, or iron sulphide (FeS_2), is probably the most harmful of all the compounds of iron occurring in clays. It is usually in the form of glittering yellow metallic particles or grains, often of cubical shape, or in concretionary ball-like masses, one to three inches in diameter, and having the surface oxidized into a brownish shell. These are popularly known as "sulphur balls," and are found in some of the shale deposits of the Indiana Coal Measures; but owing to their size are easily extracted. When present in any quantity, pyrites causes the clay constituents to fuse at a temperature much below that at which the proper vitrification takes place. In burning, it also unites with the steam driven off from the clay to form sulphuric acid, which may make the ware poor. If present in small grains or lumps and these are not crushed or removed

in the preparation of the clay, they are liable to swell during the burning and split off pieces of the ware.

Sulphate of iron, or copperas (FeSO_4) is often produced in clay deposits containing pyrites by the oxidation of the latter. Its presence may be known by the astringent, inky taste which it imparts to the clay, and usually by the presence of a white efflorescence upon the surface. Like the pyrites, it is a very damaging constituent, rendering the clay in which it is found in any quantity, comparatively worthless.

Iron carbonate, or siderite (FeCO_3), is also a quite common mineral in the shale beds of the Indiana Coal Measures. It is usually found in the form of kidney-shaped nodules, which contain more or less clayey matter, and are known as iron kidneys or clay ironstone. They vary much in size, and often occur in layers at regular intervals apart, making it easy for the clay miner to separate them. If too large a proportion of them are ground up with the shale they increase too highly the percentage of iron, and so reduce the fusing temperature. Otherwise they are comparatively harmless, as under the influence of heat the carbonate is decomposed into ferrous oxide and the gaseous carbon-dioxide ($\text{FeCO}_3 = \text{FeO} + \text{CO}_2$).

LIME AND MAGNESIA.—Some residual and almost all sedimentary clays contain lime or magnesia, one or both, in small but persistent quantities. The best clays contain less than two per cent. of these substances—though for some purposes clays containing as high as 25 per cent. of lime may be utilized. When present, lime and magnesia usually occur either as silicates or carbonates—more commonly the latter. The presence of carbonate of lime can be detected by the effervescence produced when a drop of muriatic acid is put on the clay, and dolomite (carbonate of magnesia) shows itself by acting similarly when hot acid is dropped on the rock. Like the oxides of iron their degree of harmfulness depends largely upon their physical condition. If in fine particles, thoroughly disseminated through the clay, they only act as fluxes, and so limit the use of the clay to the making of certain products. Lime, however, more commonly occurs in the drift clays or till, in the form of small grains or pebbles of the carbonate. Unless these can be removed or ground to powder by a crusher, the clays containing them are practically worthless. If

burned with the clay each lime pebble loses carbon-dioxide and is changed from a carbonate to an oxide or "quick-lime." This has great attraction for water, and when exposed each pebble absorbs moisture, swells and bursts off a piece of the ware, causing a defect or shallow pit in its surface.

Good bricks can be made of clay containing 20 per cent. or more of carbonate of lime, provided it is in a finely divided condition. If in such clays the lime present is in excess of the iron it combines with the oxides of iron and with some of the sand to form a light colored, double silicate of iron and lime. For this reason many of the alluvial and marly clays in northwestern Indiana—especially those near Hobart, Michigan City and South Bend—although rich in iron oxide, produce whitish or cream colored instead of red products. These clays are not, however, suitable for the making of paving brick, sewer pipe or stoneware as the points of incipient fusion and viscosity are so near together that they would melt down before vitrification took place. Such clays can be used in the manufacture of Portland cement, as the lime present would in no way affect their usefulness for that purpose.

ALKALIES.—These include potash and soda, two of the most powerful fluxes known, which are present in nearly all clays. They often occur as a constituent of undecomposed feldspar grains which the clay may contain, or in some cases the potash may come from mica, whose tiny glistening scales are easily discernible when present. They melt at a lower temperature and unite more readily with the clay-base than do iron, lime or magnesia. Their amount is not large, being, on an average, but two to four per cent., but in fusing power this is equal to more than double that percentage of the fluxes previously mentioned. Their presence in any quantity in clays desired for refractory purposes is, therefore, most pernicious. On the other hand, where vitrified products are to be made, it is better that some of these alkalies be present, that they may cause the clay constituents to begin to fuse and combine at the proper temperature. When the ware is raised to a temperature sufficient to melt the potash, iron, lime, etc., these fluxes fuse with the silica and give to the ware that dense, tough, non-porous condition characteristic of all so-called "vitrified" products.

The analyses of ten shales from Ohio and six from Indiana, which are used in the manufacture of vitrified brick or sewer pipe, show an average composition of about 13 per cent. of all fluxes and 84 per cent. of kaolinite and sand. Probably from 8 to 10 per cent. of the fluxes would serve all necessary purposes, but a less proportion would leave the material unvitrified and porous, and therefore of too absorbant a nature for use. As potash and soda are the most powerful fluxes known, five or six per cent. of them are equal to from eight to ten per cent. of a mixture of all the fluxes usually found in clays. Hence, it is better that no more than two or three per cent. of both be present in those clays in which vitrification is desired and in which the other fluxes occur. As a rule, the carboniferous shales now being used for making paving brick contain from two and a half to three per cent. of potash and less than one per cent. of soda.

TITANIC ACID.—This mineral is found in most Indiana shales and under-clays, but, as far as known, it has no effect either as a coloring or a fusing agent. It usually occurs in the form of small brownish black grains of irregular shape, which are supposed to be a compound of iron and titanium. Like silica, its presence is not thought to be detrimental to the clays in which it is found.

ORGANIC MATTER.—This is often found in clays and shales, especially in those of the Coal Measures. It usually occurs in the form of very finely divided plant tissue or larger portions of plants or leaves which have settled in the material during its deposition. If in quantity, it affects not only the color of the clay, but possibly its plasticity, and no doubt its absorbtive power. When in a very fine state of division it is much less harmful than if in grains of any size. If in the latter condition it is apt to leave the ware more porous than it should be, especially if vitrification is to follow. It is usually readily combustible and is burned out at a temperature much below that of the fusing point. Many of the dark colored shales which lie immediately above the seams of coal contain too much such matter to allow them to be put to any use.

WATER IN CLAY.—"Clays contain two kinds of water, namely, hygroscopic moisture and chemically combined water. Moisture is the water mechanically mixed with the clay grains, and in clays freshly taken from the bank is often as high as 30 or 40 per

cent. Shales contain but a small percentage of moisture. The air drying usually causes the evaporation of most of the mechanically combined water, and its expulsion is accompanied by a shrinkage of the mass. It ceases, however, before all the moisture has passed off, for the reason that the shrinkage stops when the particles have all come into contact with one another, but there still remain in the mass pores which hold a certain amount of moisture that is not driven off until the early stages of burning. Moisture may exert a very injurious effect on clays, in that it tends to dissolve the soluble salts which they sometimes contain, and to bring them to the surface during air drying, thus forming a scum or efflorescence. If driven off too fast during the early stages of the burning a blistering of the ware may follow.

"Combined water is present in every clay, there being nearly 14 per cent. in pure kaolin and as low as two to three per cent. in some impure or sandy clays. The sources of combined water in clays are dry kaolinite, limonite, or hydrated silicates. The combined water is driven off at a red heat, and when this occurs an additional shrinkage of the mass takes place."*

USES OF CLAYS.

No natural material can be so easily and cheaply made into the finished product as clay. It enters more largely into the necessities of our everyday life than does any other mineral resource, and the ultimate value of its products are greater than that of any other, except iron. The following are some of the uses to which materials made of clay are put in Indiana:†

DOMESTIC.—Porcelain and china ware, white earthen ware, yellow ware, stone ware and various other wares for table service and cooking use, fire kindlers, majolica stoves, polishing brick, bath brick, etc.

STRUCTURAL.—Brick, common, front dry pressed, ornamental, hollow, glazed; terra cotta, roofing tile, drain tile, glazed and encaustic tile, chimney flues, chimney pots, door knobs, fire proofing, terra cotta lumber, copings, etc.

* *Ries.*—The Clays of the U. S. east of the Mississippi River, 1903, p. 30.

† Adapted from a table given by R. T. Hill, Vol. VIII, Mineral Resources of the United States, 1891, 475.

HYGIENIC.—Urinals, closet bowls, sinks, wash tubs, bath tubs, pitchers, drain tiles, ventilating flues, absorbent brick, etc.

ROADWAYS.—Vitrified brick, sewer pipe, drain tile, etc.

REFRACTORY WARES.—Gas retorts, glass pots, fire brick, sag-gars, blocks for tank furnaces, crucibles and other assaying apparatus, stove and furnace bricks, cupola bricks, floors of kilns, blocks for fire boxes, etc.

ENGINEERING AND HYDRAULIC WORK.—Portland cement, railway ballast, puddle, water conduits, reservoir lining, sewer pipe, etc.

ORNAMENTAL AND DECORATIVE.—Tiling, ornamental pottery, terra cotta decorations, artists' molding clay, base for pigments and paints; majolica, garden furniture, etc.

MISCELLANEOUS USES.—Conduits for underground wires, stone pumps, paper sizing, electric insulators, fulling cloth, scouring soap, chemical apparatus, ink bottles, ultramarine manufacture, emery wheels, playing marbles, battery cups, pins, stilts and spurs for potters' use, shuttle eyes and thread guides, smoking pipes, umbrella stands, pedestals, filter tubes, caster wheels, cosmetics, talcum powder, food adulterants, etc.

The above products, to the value of more than twenty-five millions of dollars, are annually used in our State, while heretofore less than seven millions of dollars' worth have been produced within her bounds. Yet, with the exception of some of the clays used in the making of encaustic tile, glass pots, porcelain and china wares, Indiana contains, as I shall endeavor to show in a subsequent section, the raw material in abundance to manufacture every one of the above mentioned articles.

Very few of the above products are made from one grade of clay alone; in fact, probably 90 per cent. of the articles mentioned in the above list are molded of a mixture of at least three clays, and many clays are used for several purposes. The aim of the manufacturer in each case is to get a mixture of the proper plasticity, color-burning qualities, shrinkage and refractoriness.

SECTION II. THE GEOLOGIC DISTRIBUTION OF THE CLAYS OF INDIANA.

The surface rocks of Indiana represent five great periods of paleozoic time. These, named in the order of their age, are the Ordovician or Lower Silurian; the Upper Silurian; the Devonian; the Mississippian or Lower Carboniferous and the Carboniferous. The greater part of these formations are hidden beneath a heavy mantle of glacial drift or till which covers three-fourths or more of the area of the State. Over the greater part of the three northern tiers of counties in the State this drift is so thick that no outcrop of surface rocks occurs even in the valleys and deep eroded beds of the streams.* The available clays of these counties are of necessity, therefore, the "drift clays" and their secondary deposits, the "alluvial clays," and the "silty" or "marly" clays. It is only in this deep drift covered section of the State that fresh water lakes, many of which are now extinct, were formed. It is only here, therefore, that the silty or marly clays occur. These clays are in places being extensively used in the making of terra cotta lumber, fire proofing, and pressed front brick. They are therefore becoming of much economic importance, and the known local deposits will be treated in detail in a subsequent section.

A careful study of the drift deposits of Indiana has proven that there were several distinct glacial invasions of the State. The great ice sheet which was first formed several times advanced and as often—by an increase in the temperature of the region which it entered—melted and receded; its retreat or recession being each time as gradual as its advance had been. Like a great army which has attempted the invasion of a country and has been compelled to withdraw, it would again assemble its forces and start in a slightly different direction. But perchance, before it had reached the limit of its former invasion, a force of circumstances would render a retreat necessary. Its advancing margin was not in a straight line, but in lobes, or long, gradual curves.

The first invasion of Indiana by one of these glacial lobes was

*The counties so covered are Steuben, Lagrange, Elkhart, St. Joseph, Laporte, Porter, Lake, Starke, Marshall, Kosciusko, Noble, Dekalb, Allen, Whitley, Fulton, Pulaski and the greater part of Jasper, Newton and Benton. See the uncolored part of the large geological map, accompanying the 23th (1903) Report of this Department.

from the elevated districts to the east and south of Hudson Bay. It, in time, covered a greater area of the State than any one of those which followed. When this glacier had assumed its maximum size, its southern or front edge extended across the north-western corner of Pennsylvania and central Ohio to a point a little southeast of Cincinnati, where it crossed the Ohio River into Kentucky. Passing through Campbell, Kenton and Boone counties on a line nearly parallel with the Ohio River, and some five to eight miles south of that stream, it entered Dearborn County, Indiana, a little below Aurora, whence it passed in a southwesterly direction through Ohio and Switzerland counties and crossed into Trimble County, Kentucky. Here it turned more to the west, recrossed the Ohio into Clark County, and reached its southernmost point in this portion of the State near Charlestown. From here it bore to the north through Scott and eastern Jackson counties, and then followed approximately the line shown on the accompanying map until it entered Illinois. Since this first or oldest glacier covered most of the latter State, the name "Illinoian" has been given to the drift material which it brought down. The terms "older glacier" and "older drift" are sometimes also used when referring to it and its deposits. It is probable that the margin of this first ice sheet occupied only a portion of the glacial boundary, as shown in Indiana, at any one time.

After reaching the line marked on the map as the "Approximate Glacial Boundary," the ice of this first glacial invasion melted away and left its drift, composed of a motley mass of materials, exposed to the agencies of water, wind and frost. What is known as the "*First Interglacial Interval*" then ensued, during which a vegetation arose on the surface of the Illinoian drift and for a long period flourished and decayed, in the manner as does the vegetation of our present surface. As a result a black mold or soil was gradually formed, which is now concealed beneath deposits of silt called "loess" in southwestern Indiana, and beneath the drift of later glacial invasions in the northern part of the State. How long this "interval" lasted no one knows, but evidently hundreds of years, as shown by the thickness of the soil mentioned and by other evidence which the geologist can take into account.

A "Second Glacial Epoch" or invasion then occurred, during

which the ice brought down much thicker deposits of drift than in the first. At many points east of Indiana this second glacier extended much farther south than the first, but in this State its Southern border only reached the dotted line shown on the map

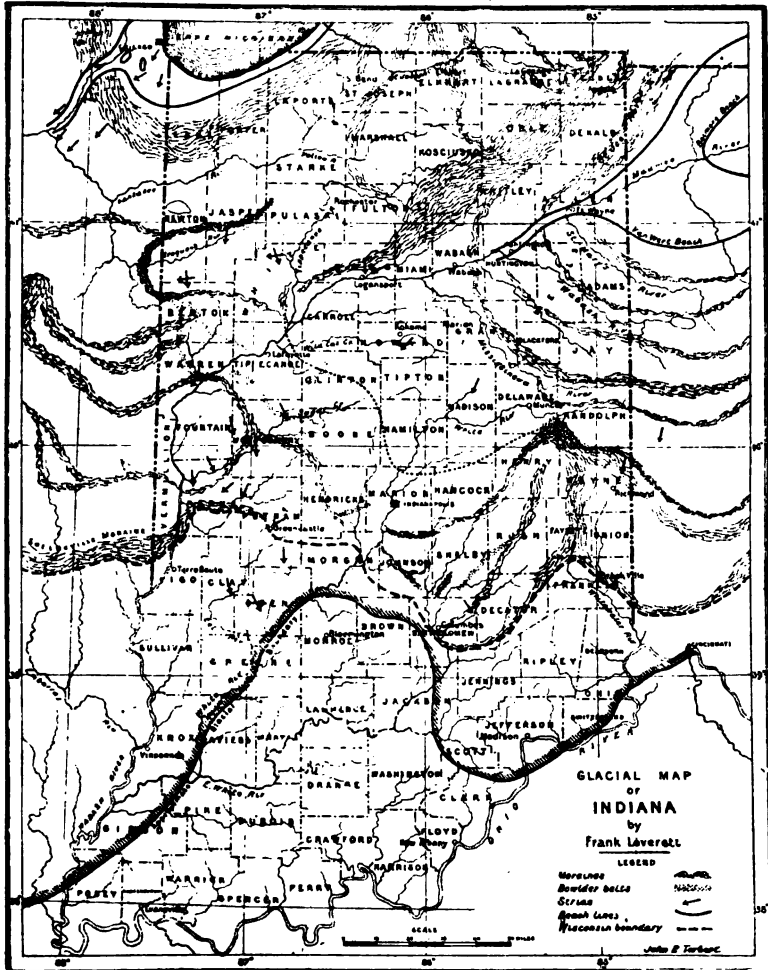


Fig. 1. Map showing the Approximate Glacial Boundaries in Indiana.
(From "Studies in Indiana Geography," p. 28.)

and named by Professor Chamberlain, the "Wisconsin Boundary," because this glacier invaded the driftless area of that State farther than any other. Of the drift in Indiana brought down by this second glacial invasion, Professor Chamberlain has writ-

ten in part as follows: "The border of the 'newer drift,' slightly ridged, may be traced diagonally across the northeastern part of Montgomery County, the center of Hendricks, the northeast corner of Morgan, the southwest portion of Johnson, striking the basin of the East White River near Edinburg. On encountering this basin the newer drift border comes in association with the remarkable fluvial phenomena of "Collett's Glacial River." This was one of the great avenues of discharge from the ice border, and has left its record in broad belts of gravel gathering into a great trunk stream. The edge of the newer drift sheet is interrupted and obscured by these fluvial deposits, but it seems to have formed a lobe, reaching down the basin into Jennings County, the glacial river lying on its western border. The eastern edge of the loop runs north diagonally across Decatur County, the southeastern portion of Rush, the northwestern part of Fayette, and of Wayne, in the northern portion of which, and the southern part of Randolph, it recurves to the southeast to form the Great Miami Loop in Ohio."*

The drift clays form a very large percentage of the morainic material or till which was dropped where it now lies by the melting of one or more of these great ice sheets or glaciers which invaded Indiana. The clays and other components of the later or Wisconsin drift can generally be readily distinguished from those of the earlier or Illinoian sheet by their softness and fresher appearance. In sinking wells, it is easy to excavate with a spade the clay and other material of the newer drift, while picks and sometimes explosives must be used in the older. The hardness of the older till sheet is largely due to the forming of a crude natural cement by the clay and carbonate of lime.

In the counties covered by the Wisconsin drift the clay immediately below the soil is usually buff to reddish yellow in color, the hue being due largely to the free action of the oxygen of the air on the oxides of iron present in the clay. At a depth of five to fifteen feet from the surface this usually merges gradually into a grayish blue compact clay. This has nearly the same chemical composition as the upper deposit but has been less affected by oxygen.

*"The Terminal Moraine of the Second Glacial Epoch," in Third Ann. Rep. U. S. Geol. Surv., 1883, 333.

In the area covered only by the first or Illinoian glacier the yellow clay is not so common. The materials of the surface clay of this area were derived from a different source and the clay was more "sticky" or of a tough plastic nature, nearly impervious to water. Blue gray in color when first deposited it has, by weathering, been leached to a gray white and forms the so-called "white clay" soils of southeastern Indiana. Wherever these soils occur, the clay beneath them is harder than at corresponding depths in the newer drift.

THE ORDOVICIAN OR LOWER SILURIAN.—The rocks of this period are the oldest in the State and come to the surface only in its southeastern corner, where they comprise the surface of all or a part of the following counties: Wayne, Union, Fayette, Franklin, Dearborn, Ripley, Ohio, Switzerland and Jefferson. While the drift covers all of this area, it is everywhere quite thin and in the valleys and the beds of the streams the surface rocks are exposed. These exposed rocks belong, for the most part, to the Hudson River epoch, and consist chiefly of blue calcareous shales interbedded with a highly fossiliferous limestone. The clay from these shales, when weathered, becomes very soft and plastic, but on account of the high percentage of lime and particles of sand which it holds, is worthless for manufacturing purposes. The drift and alluvial clays of the area are utilized in a number of localities for ordinary brick and drain tile, but only for local use, as they are in general of inferior quality. On the whole, the Ordovician area of the State may be said to offer but limited attractions to clay manufacturers.

THE UPPER SILURIAN.—To this geologic period belong the surface rocks of a large area of eastern and north-central Indiana, comprising part or all of the following counties: White, Cass, Miami, Wabash, Huntington, Wells, Adams, Jay, Blackford, Grant, Howard, Tipton, Madison, Delaware, Randolph, Wayne, Henry, Hancock, Hamilton, Rush, Fayette, Decatur, Ripley, Jennings and Jefferson.

The Niagara limestone, the leading formation of this Upper Silurian period, comprises in places in its basal third some beds of bluish green shales and clays* which vary in total thickness

*Notably the Osgood and Waldron clays of Forste, for an account of which see the 22d, 24th and 28th reports of this Department.

from two to 20 feet. They contain, however, too much lime and magnesia to be used for clay products.

The only commercial clays of any value in the entire Upper Silurian area of the State are, therefore, derived from the drift and alluvium. The drift clays occur throughout the area and are used on a large scale at Marion, Muncie and Anderson in the making of ordinary brick and at Summittville in the making of a partly vitrified drain tile. At numerous other points in the area ordinary brick and tile yards of smaller size are in operation. At few places, however, can the drift clays be used to a greater depth than three feet, as they usually contain, below that depth, too many lime pebbles and other foreign impurities. A factory of any size must, therefore, control a large area of surface in order to possess raw material sufficient for any length of time.

THE DEVONIAN.—The rocks of this period form the surface of a great area, extending northwest and southeast through the central part of the State, but offer little of promise to the clay worker. They outcrop or are known to occur beneath the surface in Clark, Scott, Jefferson, Jennings, Jackson, Bartholomew, Decatur, Rush, Shelby, Johnson, Marion, Hancock, Hamilton, Boone, Clinton, Tipton, Carroll, Cass, Tippecanoe, White and Jasper counties. Thick beds of the brown to black New Albany or Genesee shale cover a strip six to 18 miles wide in the western part of this area, but they everywhere contain too high a percentage of bituminous matter to burn into clay products.

The entire Devonian area, except a small portion of Clark and Scott counties, is drift covered, and the surface drift and alluvial clays are, in numerous places, utilized for ordinary brick and drain tile making. Otherwise the Devonian area in the counties mentioned contains no clay deposits of value.

THE MISSISSIPPIAN OR LOWER CARBONIFEROUS.—The epochs of this geologic period as represented in the Indiana rocks are the Goniatic Limestone, the Knobstone Shale, the Harrodsburgh, Bedford and Mitchell Limestones, and the Huron Limestones and Sandstones. They form the surface rocks over a strip of territory 40 miles or more in width, lying between the western edge of the Devonian and the eastern edge of the Carboniferous rocks, and extending from the Ohio River in a northwesterly direction to the Illinois line in Benton and Newton counties. The follow-

ing counties, therefore, lie either partly or wholly within this Lower Carboniferous area: Benton, Warren, Tippecanoe, Fountain, Montgomery, Boone, Hendricks, Putnam, Owen, Morgan, Johnson, Bartholomew, Brown, Monroe, Greene, Lawrence, Jackson, Scott, Washington, Orange, Crawford, Perry, Harrison, Floyd and Clark.

The area embraces the greater part of the driftless region of the State, in which occur the residual surface clays, derived mainly from the decay of the underlying limestone or sandstone rocks. Where formed from the limestone, these residual clays are usually a deep red color, due to the presence of a high percentage of iron oxide, but, nevertheless, are often well adapted to making brick and tile. Although derived from calcareous formations, the weathering leaches out most of the lime carbonate. They often contain small angular pieces of the parent limestone which increase in number and size as the parent rock is approached. The depth of these residual deposits varies with the depth to which the weathering has penetrated the parent rock and also with the surface slope on which the clay has been formed. On steep slopes these clays seldom show great thickness, since they are easily washed away, but in valleys and on flat surfaces their thickness may be great.

In the Lower Carboniferous area these surface residual clays occur over all of Monroe, Lawrence, Orange, Harrison and Floyd counties, and over the western halves of Brown, Jackson and Washington and the eastern halves of Greene, Martin, Perry and Crawford counties. Most of the brick and drain tile manufactured in the counties mentioned are made of such clays, and at Bedford it is the intention to use them, in part, as the clay ingredient of Portland cement at the factory of the United States Portland Cement Company. The surface clays of the remaining portion of the Lower Carboniferous area are either drift or alluvial clays, which are used in many localities for brick and tile manufacture.

Knobstone Shales.—Aside from the surface clays above mentioned, the only clays of economic importance occurring in the Lower Carboniferous area are the shales of the Knobstone epoch. These shales have, as yet, received but little attention from clay manufacturers, but they are destined to become—next to the

shales and under-clays of the Coal Measures—the most important commercial clays of the State.

Edward Orton, Sr., in a paper on "The Clays of Ohio, Their Origin, Composition and Varieties,"* speaks of the division of the Waverly shales of that state which correspond to the Knobstone shale of Indiana "as a great stratum 160 to 450 feet in thickness, consisting of light colored blue or gray shales which have unlimited possibilities of service in the practical way, but which have been almost completely ignored thus far. Their day, however, is sure to come. Their adaptation to paving block manufacture in particular will be recognized and it will be at once shown, as soon as it is used, that no better material for this purpose is found in our entire series than this shale can supply."

The Knobstone group forms the surface rock of a strip of territory on the eastern side of the Lower Carboniferous area, three to 38 miles in width, extending from the Ohio River southwest of New Albany in a west of north direction to a point a few miles south of Rensselaer, Jasper County. The group reaches a maximum thickness of 650 feet at Bloomington, near the center of the State. At St. Joseph, in Floyd County, it is 550 feet; at Rockville, Parke County, it is 530 feet, while near New Albany, in the southern part of the State, it is 471 feet in thickness. Over much of the northern part of this area the Knobstone is in most places covered by a heavy mantle of glacial debris, its outcrops being exposed only along the stream valleys. Where the strata are cut through by the larger streams, bluffs are often formed. Such bluffs are to be seen along West White River about Martinsville; along Sugar Creek above and below Crawfordsville, and along Shawnee Creek south of Attica. At all of these localities are excellent exposures of the Knobstone strata. Deep wells and bores have also proven it to be the surface rock below the drift in many places, where exposures are absent. Its outcrops are known to occur in the following counties: Harrison, Floyd, Clark, Washington, Scott, Jackson, Lawrence, Monroe, Brown, Bartholomew, Johnson, Morgan, Owen, Putnam, Hendricks, Marion, Boone, Montgomery, Clinton, Tippecanoe, Fountain, Warren, White, Benton and Jasper.

The Knobstone group was so named as early as 1837, by D. D.

* Geol. Surv. of Ohio, VII, 1893, 58.

Owen, because of the peculiar conical hills or *knobs* which occur over its weathered outcrops.* The name "New Providence shale" was also given, by Borden, in 1873† to the soft greenish or bluish shales forming the base of the Knobstone in the vicinity of New Albany and New Providence. Of it he wrote as follows: "This shale lies at the base of the Knobs and has a thickness from 80 to 120 feet. As you follow the line of the Knobs to the northwest it becomes thinner. It is a fine greenish colored shale that pulverizes when dry without difficulty."

In general the rocks of the Knobstone consist of blue gray shales, shaly sandstone, sandstone and rarely a little limestone. In central and southern Indiana, where they are best developed, the group is divided by Newsom into (1) the New Providence shale at the base, overlain by (2) the Upper Knobstone shale and (3) the Knobstone sandstone. There is considerable variation locally in the relative percentage of sandstone and shale, with the shales prevailing at the base of the group and sandstone at the top. The color is prevailingly bluish gray to greenish gray, changing to buff on the much weathered exposure.

Many nodules of siderite or iron carbonate of considerable size are found in the knob shales, and these sometimes occur thickly strewn over the surface. Their manufacture into iron has been advocated at one time and another, but they do not occur in sufficient quantity at any place to be valuable for that purpose. When these siderite concretions are broken up and worn into creek gravels, however, they make an excellent road metal, for which purpose they are used in Floyd, Jackson, and other counties of the area.

"The three divisions of the Knobstone group, as outlined above, can be best recognized in the extreme southern part of the State, where the shales predominate, and where the entire group has its best development. Further north, however, in Jackson, Brown and Bartholomew counties, the entire group is made up of alternating impure sandstones and clay shales in which the sandstones predominate.

"Where the Knobstone strata outcrop along Sugar Creek, near Crawfordsville, the bluish, massive, sandy shales predominate.

* Report of a Geological Reconnaissance of the State of Indiana, made in 1837, p. 21.

† Fifth Annual Report Indiana Geological Survey, 1873, p. 161.

"The type sections show the general character and relations of the beds composing the Knobstone group in different parts of the area covered by that formation."*

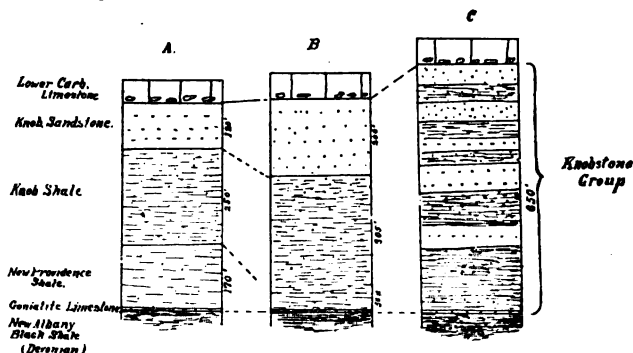


Fig. 2. Three type sections of the Knobstone group.

- A. Section in Floyd County, just west of St. Joseph postoffice.
- B. Section on the middle line of Township 3 north.
- C. Section on the north line of Township 8 north, adapted from Bennett's cross section.

A noticeable feature throughout the whole Knobstone area, where the valleys are well developed, is that the south-sloping hillsides have much steeper slopes than the north-sloping areas. This difference is thought to be caused by the different temperature changes. Thus the hillside sloping south faces the winter's sun, which thaws it during the day and it freezes again at night. It is this constant freezing and thawing which weathers the shale much more rapidly than on the north-facing hillside, which lies in the shadow and is often covered with snow for many days and weeks, when the sun and frost are disintegrating the south-facing hill.

There is some difference also between the east and west sides of the north-south valleys, but it is not so marked as in the preceding. The slope on the east side receives the afternoon sun, which is warmer than the morning sun, and hence the tendency is to weather more rapidly, but the difference is not so marked as in the east-west valleys.

A characteristic feature of the weathering of the Knobstone on all the cliff exposures is the exfoliation or the flaking off of thin slabs parallel with the surface and independent of the bed-

* *Newsom*.—"The Knobstone Group of Indiana." In Twenty-sixth Annual Report Indiana Department Geology and Natural Resources, 1901, pp. 260-279.

ding. These foliation planes are sometimes so pronounced as to be mistaken for the bedding planes.

There is not the alternation of hard and soft layers so common in many limestone beds, and hence the absence of rock terraces caused by such alternation. While there is a uniformity in the relative hardness and weathering qualities of the different layers, there are irregular patches and pockets of softer and harder materials, so that the weathered surface is sometimes pitted by the weathering out of the softer spots and sometimes studded with siliceous concretionary masses.

The New Providence shales, comprising the basal formation, wherever they occur, will be found suitable for paving brick, pressed front and ordinary brick and the clay ingredient of Portland cement. When properly ground they become plastic enough to form a good sewer pipe clay, but when utilized for that purpose some difficulty was experienced in glazing the product. Otherwise it was of excellent quality.

These shales are already being utilized on a large scale at New Albany for the making of both ordinary stiff mud and dry pressed brick.* At the plant of the Hoosier Brick Company, two miles southwest of the city, these shales are 150 feet thick, as proven by the exposure in the pit and a deep bore sunk for a well. According to Newsom, they thin out to 50 feet or less at the south side of Scott County, while north of Township 3 north, they merge into the overlying "Upper Knobstone shale."

This upper shale consists of a series of soft light gray or greenish shales, which vary in composition from soft clay shale towards the bottom, to an impure, fine grained sandstone at the top. In Township 2 south, 6 east, this shale has a thickness of 200 feet, while in Township 3 north, it has increased to 250 feet. At Blue Lick, Jackson County, this upper Knobstone shale is quarried in quantity and shipped to Mitchell, where it is used as the clay ingredient of Portland cement at the large factory of the Lehigh Portland Cement Company.† There is no apparent reason why this same shale from numerous other parts of the Knobstone area should not be used for the same purpose. Points that would appar-

* For analysis and detailed description of the New Albany deposits, see "The Clays of Floyd County," in another section.

† For a full account and analysis of this deposit of shale see "The Clays of Jackson County," on a subsequent page.

ently indicate an increased use of the Knobstone shale in cement making are (1) its proximity to the excellent limestone beds overlying it and its short distance from the coal fields; (2) uniformity in composition, and (3) ease of quarrying and preparation. In many places the shale and the limestone may be obtained from the same hillside, but generally it may be found more desirable to quarry them at different points because the limestone immediately overlying the Knobstone is generally not a good limestone for cement purposes. The shales may be a little harder to pulverize and mix with the lime ingredients than the softer clays that are sometimes used, but this is more than counterbalanced by greater uniformity of composition and great thickness of the beds.

That the same shale is in every way suitable for brick making is proven by the practical use of it at the large plant of the Adams Brick Co., at Martinsville, Morgan County, where 40,000 ordinary soft mud brick are made from it each working day in the year; and at Crawfordsville, Montgomery County, where from it the same number of stiff mud paving blocks are made daily. It is probable that this upper Knobstone shale will be found too "lean" to be made into sewer pipe and drain tile. By mixing two parts of it with one of a more plastic clay, such as one of the under-clays of the Coal Measures, it will, without doubt, make the best of such products.

In locating a large factory for clay products in any part of the Knobstone area care should, of course, be taken to select a locality where the shale is not too sandy and has the proper composition. Then with a man in charge who is experienced in manipulating and burning clay wares, as good, if not better products can be made from the Knobstone shales as from the more widely known carboniferous shales which have come into such extensive use during the past decade.

CARBONIFEROUS.—The rocks of this period embrace by far the greatest variety and the most valuable of the clay deposits of Indiana. Covering an area of 7,500 square miles of the western and southwestern portions of the State, they comprise the surface of all of the following 14 counties: Vermillion, Parke, Vigo, Clay, Sullivan, Knox, Daviess, Gibson, Pike, Dubois, Posey, Vanderburgh, Warrick and Spencer and, in addition, the principal

part of Warren, Fountain, Owen, Greene, Martin and Perry counties. The Carboniferous area of the State thus has a maximum length north and south of about 200 miles and a maximum width from east to west of about 100 miles, being narrow to the north and broad to the south.

The counties mentioned comprise the newest part of Indiana, i. e., it was the last to be raised above the surface of the water and become dry land. The outcropping or underlying rocks of the remainder of the State were all deposited in salt water, mostly at great depths, and were raised upward and became dry land thousands of years before the coal and its overlying shales were formed. They are, therefore, for the most part, *limestones*, and the many fossils which they contain are mostly of marine animals. The rocks of the coal measures were mainly deposited in fresh water and are, for the most part, *sandstones and shales*. These contain few fossils and they are largely the remains of such plants as formed the coal.

It is most probable that at the time of the formation of the coal and its overlying shales and sandstones the area comprised in the counties mentioned, as well as the greater part of Illinois and the western third of Kentucky, was a great basin or depression but little above the level of the sea, and surrounded on every side except the southwestern by the higher lands of the older formations.

By successive alternations of upheaval and subsidence—carried on through thousands of years—this depression was at times an area of the southwestern sea, again a fresh water lake, and then for a period, a vast swamp or marsh. When raised high enough to form a marsh a luxuriant vegetation sprang up from the ooze and mud at its bottom, flourished for centuries—the newer growths springing from between the fallen masses of the older as in the peat bogs of today—and so formed a mighty mass of carbonaceous material.

By subsidence the level of the marsh was in time lowered until it became a lake into which rivers from the surrounding highlands flowed, bearing with them millions of tons of clayey sediment and disintegrated quartz, the remains of the older decayed rocks. This sediment was spread out over the mass of submerged vegetation, compressing it into the hard, mineral coal; the clayey

sediment itself being in time compressed into vast beds of *shale*, and the particles of quartz into sandstone. In some places a more prolonged subsidence took place, sinking the floor of the lake below the level of the sea, and allowing the waters of the latter, with their accompanying marine forms of life, to flow in. In time beds of limestone were then formed over those of the shale or sandstone, but none of these cover an extensive area or are of great thickness.

After each subsidence, with its resulting beds of coal, shale and sandstone or limestone, had taken place, an upheaval followed. The floor of the sea or lake was again raised so near the surface that the semi-aquatic vegetation for a new coal seam could spring up and, in time, the processes detailed above were again undergone. Thus, in brief, do scientists account for the origin and formation of those five great veins of coal which are today the chief mineral wealth of our State, and of those vast beds of overlying shale which, in recent years, have come to be used for so many varied products.

Lying at the base of the Carboniferous area, and therefore forming a dividing belt between the Lower Carboniferous limestones on the east and the coal producing beds on the west, is a great stratum of sandstone and conglomerate, known as the Mansfield sandstone, or Millstone Grit. It thus forms a bed of coarse-grained, siliceous material on which rests the clays, shales and coals of the Coal Measures proper. It denotes a period of subsidence and inflow of the sea. Previous to its deposition there had been an elevation of the land and erosion had cut numerous valleys to varying depths. The incoming sea gathered up the fragments of rock waste and formed deposits over the newly formed or forming sea bottom, filling all the depressions of the former land area, thus forming a mantle of sand, gravel, clay and coal, which rests unconformably upon the underlying uneven surface. Out from the beach, in the deeper water, deposits of fine sand and mud were formed on which, as they reached the surface, swamps and bogs developed which later became coal beds.

Kaolin or "Indianaite."—The only coal of any note found in or below this Mansfield sandstone is coal I, usually in a thin vein, which, in many places, lies at the base of the sandstone and just above the Huron sandstone or limestone of the Sub-carboniferous

period. In a number of localities in Lawrence, Martin and Owen counties coal I is replaced by a bed of *kaolin* called "Indianaite," which is the purest form of clay occurring in the State. Whenever this kaolin is found it is always at the horizon of coal I. The coal and kaolin are never found at the same place, though often they occur but short distances apart. At Huron, Lawrence County, where the best known deposit is located, the kaolin lies in a horizontal stratum, four to 11 feet in thickness, which is overlain by sandstone, and in places contains a light green mineral known as allophane. The upper half of the kaolin stratum is chiefly composed of massive snow-white clay, associated with which, near its upper part, are occasional concretionary masses, some of them a foot or more in diameter. These disintegrate on exposure to air, but the kaolin is non-plastic. The lower half of the kaolin ranges from pale buff to a rich, deep brown in color. An analysis of this kaolin made by Noyes for the Twentieth report of this Department, shows its composition to be as follows:

<i>Analysis of Indianaite.</i>		<i>Per Cent.</i>
Silica		44.75
Alumina		38.69
Water		15.17
Ferric oxide .....		.95
Lime .....		.37
Magnesia .....		.30
Potash .....		.12
Soda .....		.23
		<hr/> 100.58

Although the purest clay in the State, this kaolin is not now put to any use.* For a number of years it was made into alum sulphate for paper sizing, but on account of the cost of transportation the mines were in time abandoned. Mixed with a small quantity of plastic under-clay, it could be made into the finest of refractory wares and other products where a very pure clay is required.

There has been much discussion as to the origin of this kaolin. It is undoubtedly residual in nature; i. e., it was formed where it now lies. The material of which it was formed was, however,

*For a detailed account of the various known deposits, analyses, etc., see under "The Clays of Lawrence, Martin and Owen Counties."

sedimentary, as the nature of the bed and adjacent rocks plainly indicates.

It was formerly thought that the kaolins occupy a space which at other points is filled by a stratum of limestone in the Coal Measure rocks. Prof. E. T. Cox so thought, and in 1874 wrote regarding it as follows: "The clay (kaolin) lies immediately beneath the Millstone grit or pebbly conglomerate of the coal measures and here occupies the place of a bed of Archimedes limestone which is seen *in situ* about two miles southeast of the mine. Though similar in its chemical composition to kaolin, this clay differs physically and owes its origin to an entirely distinct set of causes and effects. While the former is derived from the decomposition of the feldspar of feldspathic rocks, such as granite, porphyry, etc., the porcelain clay of Lawrence County has resulted from the decomposition, by chemical waters, of a bed of limestone and the mutual interchange of molecules in the solution, brought about by chemical precipitation and affinity." * In other words, he asserted that the kaolin is the result of the chemical action of carbonated water upon the beds of limestone, but did not attempt to explain how carbonated water can change the elements, calcium and carbon, into silica and alumina.

Maurice Thompson upheld Prof. Cox's theory,† but added the explanation that rain water, in percolating through the overlying conglomerate sandstone, gathered and carried down with it sufficient silica and alumina to replace the carbonate of lime dissolved.

W. H. Thompson went a little more into detail and states his conclusions as follows: "In the beginning, then, we have a stratum of limestone of a soft and destructible nature, immediately above which lies a massive sandstone formation of coarse grain and loose texture.

"Everybody knows that rain water will percolate easily through massive coarse sandstone, and in this case it did so percolate and thus reach the underlying limestone which it slowly destroyed, the first step being the bearing away of the lime and iron, these being the elements most readily affected by the water. The residuum now left of the limestone is composed of silica and alumina; meantime, the water passing through the sandstone has

*Sixth Ann. Rep. Geol. Surv. of Ind., 1874, p. 15.

†Fifteenth Ann. Rep. Ind. Dep. Geol. and Nat. Hist., 1886, p. 37.

been taking therefrom silica and alumina, with a trace of mica in a fine state of mechanical division, and bearing them down to the cavity below, where by chemical action they combine with the silica and alumina left over from the destruction of the limestone. Thus, in short, was the kaolin of Indiana made.”*

All of these writers had evidently overlooked the fact that as far back as 1861 Prof. Leo Lesquereaux had recognized that the kaolin near Dover Hill, Martin County, occupied the horizon of a missing vien of coal, and gave it as his opinion that the kaolin was the result of the burning out of the coal beds. His account of the Dover Hill deposit is as follows:

“On both sides of the place where the coal is worked there is a bank of very soft, ochrous clay, a true powder as fine as flour, without any trace of coal, though occupying exactly the same horizon. It is overlaid by a clay iron ore, which looks as if it had been roasted. I consider this local formation as the result of the burning of the bank of coal at places where it was exposed along the creek.”†

Dr. Geo. H. Ashley, who has made the most careful survey of the Indiana coal fields to date, concludes that Lesquereaux was right in his theory, and that the kaolin was formed by the combustion of a vein of coal immediately above a vein of under-clay, the impurities of the latter being burned out, and the kaolin left as a residue. I quote from him as follows: “In the first place, the absence of the coal where the kaolin occurs does not appear to be due to the thinning out of the coal; for, on the other hand, it was found in places that the coal, which occurs often but a few rods away, is of an unusual thickness as, for example, on the Johnson and Chenoweth place, west of Shoals, the coal and kaolin are only separated by a narrow ravine. On the west, coal I is about 3 ft. 4 in. thick, and apparently does not lie in a small pocket, while east of the ravine is found the kaolin in the same horizon. Moreover, in addition to the iron ore mentioned by Mr. Lesquereaux, the deposit is frequently overlain by a soft, pinkish sandstone. A similar sandstone is observed at a place on Roaring Creek, in Parke County, where the bed of coal has been burned

*Sixteenth Ann. Rep. Ind. Dep. Geol. and Nat. Hist., 1888, p. 78.

†Report on the Distribution of the Geological Strata in the Coal Measures of Ind., *In Rep. of a Geol. Recon. of Ind.*, made in 1859 and 1860, p. 320.

out beyond all question. Another factor is the apparent resemblance often observed of baked fire-clay to kaolin." *

While the facts at hand are not sufficient to fully justify either of the conclusions above given as to the origin of the kaolin, that of Lesquereaux and Ashley is by far the more plausible. It at least accounts, according to the laws of chemistry, for the presence of the silica and alumina which, with the combined water, make up 98.61 per cent. of the deposit.

NOMENCLATURE OF THE COAL MEASURE ROCKS OF INDIANA.— Since the under-clays and shales of the Coal Measures form the most valuable commercial clays of Indiana, they will be treated more fully than those of the other geological formations in this report. In discussing them the nomenclature and numbers of the coal veins adopted by Ashley in his report on "The Coal Deposits of Indiana,"† will be used. It is thought best, therefore, to incorporate here the following explanation of the Ashley system of nomenclature as given by him on pages 87 to 91 of the report cited:

Ashley System of Nomenclature of Indiana Coal Veins.

The work of the present survey has brought out the following points:

1. No single stratum of rock or coal in the coal measures, with possibly the exception of the basal sandstones, is persistent over the whole coal field, or even between the extreme points of its extent.
2. That, as a rule, the coal beds are a little more persistent than any of their accompanying rock strata.
3. That a thick coal bed is usually more persistent than a thin bed.
4. That the upper beds of the coal measures are usually more persistent than the lower, their accompanying strata also being more persistent than the strata accompanying the lower beds.
5. That often when a coal is lacking, the position of its horizon is shown by the accompanying strata.
6. That the horizon of certain coals can be traced persistently, if time and detailed study be given to it.

For the simple part of our system it is therefore proposed to

*Twenty-third Ann. Rep. Dep. Geol. and Nat. Res., 1898, p. 931.

†Twenty-third Ann. Rep. Ind. Dept. Geol. and Nat. Res., 1898, pp. 1-1573.

divide the coal measures vertically into eight spaces or divisions to be designated by the Roman numerals I, II, III, etc., these divisions to be based on the position of some principal coal beds or horizons. In order to give definiteness to the system, it will be based on the vertical position of the worked coals as found in northern Clay and Vigo counties, that region being chosen principally because of the abundant developments in that area having rendered the relative position of the principal beds quite certain, in many cases two or three of the beds chosen being found in the same shaft.

Along the eastern edge of Clay County, and in general along the eastern edge of the Indiana coal field, occurs a very persistent massive sandstone. This is sometimes a fine conglomerate or grit and was called the Millstone grit or conglomerate by the first survey, or more recently the Mansfield sandstone. This sandstone is frequently underlain by one or two coal beds of minor importance. The sandstone and accompanying underlying coals are separated from the rocks both above and below by slight unconformabilities. It thus becomes a distinguishable division of the coal measures and the vertical space which it is supposed to occupy will be called Division I.

The main worked coals all occur above Division I; of these there are four in northern Clay County and two additional beds in Vigo County, while in southern Indiana coals occur between the lower block coal in Clay County and the Mansfield sandstone. The minor beds occurring in the same space, some of which are very locally of good, workable thickness, will not now be considered.

We have here, then, the basis for seven space divisions. Of these the uppermost coals can be traced with considerable certainty, the coal at West Terre Haute being persistent and traceable the whole length of its outcrop. The next coal below it, locally known as the "big vein," while not so persistent as the coal above, has, we believe, been traced as a horizon from the Ohio River to northern Warren County. The "rider" at Brazil, while not very important or readily recognized in the northern part of the field, to the south appears as a continuous coal bed for 100 miles and can be traced readily and with great certainty. Descending from this the coals appear in smaller and smaller

basins, and correlation is attended with more and more uncertainty, so that the conviction has grown upon the members of the survey that the lower coals do not occur at widespread horizons, and therefore any attempts at exact correlation between distant points will be fruitless. However, as workable beds are found in this space, and as some of these beds are of great importance, it becomes desirable to extend our system to them. As it is found that workable coals occur at such distances below the "rider," as traced, as to divide the rocks into from one to three divisions, according to the aggregate thickness, it will be convenient to divide the time space represented by these rocks into three divisions to be known as Divisions II, III and IV. The upper and lower block coals will be known as Coals IV and III, respectively. The rider, most typically developed at Petersburg, Pike County, where it is 8 to 10 feet thick, will be called Coal V. The "big vein," worked at Turner, Staunton, Seeleyville, Coal Bluff, Coxville, etc., will be known as Coal VI.

The space from any one of these coals to the next will be known as a division. Thus, Division VI will comprise all of the rocks from Coal VI to Coal VII, including Coal VI.

Above the "big vein" at Seeleyville is a coal bed of frequently or generally workable thickness. It is the bed worked above drainage at Clinton and Lyford, and believed to be the bed extensively worked at West Terre Haute. A workable bed at a similar height is commonly found, though on account of the presence of the thicker "big vein" it is but little worked commercially. The space from the big vein to it will constitute Division VI. Still above the bed last mentioned is a coal bed which locally, along Coal Creek, Vigo County, and Brouillett's Creek, Vermillion County, is of workable thickness. Division VII will extend to this coal bed from the bed last mentioned.

At Merom, Sullivan County, the coal worked by shafts is believed to be at this horizon. Near the top of the bluff at the same place is a massive sandstone, called in the old reports the Merom sandstone. It lies unconformably upon the rocks below, and as no coal has ever been reported as found in it or above it, it is taken as marking the top of the coal-bearing rocks of the State. The space from it down to the coal mined by shafts at about river level at Merom will be taken as Division VIII.

The age of the Merom sandstone is in doubt, but temporarily it, with any overlying rocks, exclusive of the drift, will be considered as in Division IX. It will be noted that with the exception of Divisions II and IX, a major coal is taken as the bottom of each division, so that in representing the outcrop of any division on the map, the bounding lines will practically represent the lines of outcrop of the coals at the top and bottom of the division. The coal at the bottom of the division in each case will be considered to be in that division, and in general will be designated by the number of the division in which it is included. Thus, the "big vein" at Seeleyville, etc., will be called Coal VI; the rider at Brazil, Coal V; the top block at Brazil Coal IV, etc.

In the majority of cases one or more minor coal beds occur between the major beds. In all cases where more than one coal is assigned to a division, the coals will be distinguished by the addition of a, b, c to the Roman numeral. Thus, three coals in Division V would be called Coals V, Va, Vb. In cases where it is known that a coal bed or group of beds are above a certain division, as say Division II, and below another division, as say Division VI, but data is lacking for any closer adjustment to the time scale, it may be named by the combination of two or more divisions; as, in the case above, it might be called Coal III—V.

The Coal Measure Shales and Under-Clays.—A part of a typical vertical section showing the arrangement of the different strata of the Coal Measures and their relations to each other would be about as follows:

Typical Coal Measure Section.

	<i>Fect.</i>	<i>Inches.</i>
1. Soil and surface clay.....	5	2
2. Sandstone, massive or shelly.....	2	8
3. Blue compact shale.....	27	0
4. Coal—VII	4	10
5. Fire-clay	6	2
6. Drab siliceous shale.....	18	0
7. Limestone	3	8
8. Black bituminous shale.....	2	4
9. Coal VIb		8
10. Fire-clay	5	6
11. Sandstone	13	0
12. Dark gray shale.....	11	2
13. Coal VI	6	3
14. Hard bastard bluish fire-clay.....	11	0

15. Sandstone	21	0
16. Blue limestone	11	0
17. Black sheety bituminous shale.....	5	4
18. Coal V.....	5	2
19. Fire-clay	4	8

Some of these strata are closely related. The fire-clays Nos. 5, 10, 14 and 19, are almost universal accompaniments of the overlying coal seams. The relation of these under-clays to the coal show plainly that the former may be regarded as having formed the soils of the ancient Carboniferous marshes, and that from them sprang that luxuriant vegetation which in time was changed to coal. The fire-clays, then, are the mother soils of the coal seams. They are usually from one to six feet in thickness, and composed of a soft, homogeneous clay, whitish or gray in color, highly plastic and, when sufficiently free from the fluxing elements, capable of withstanding in a remarkable degree the action of heat. Occasionally, however, these under-clays are composed of a hard, bluish, very siliceous clay containing more or less pyrites and other impurities. No. 14 of the above section, found beneath coal VI, is such an under-clay. Similar clays usually occur beneath coals V and III, while those beneath coals VIII, VII, IV and II and several of the thinner rider veins are usually of excellent quality for manufacturing purposes.

It is important to remember that these under-clays of the coal seams are the only sedimentary clays in Indiana which possess in a high degree the property of infusibility or refractoriness. Its presence in them is due to the absence of a large percentage of the alkalies and other fluxes. This absence is the more notable since all other sedimentary clays contain these fluxes in quantities sufficient to cause fusion at a comparatively low temperature. Their disappearance from the fire-clays is explained by the fact that these clays formerly supported so vigorous a growth of aquatic plants; for it is a well proven fact that such vegetation, aided by organic acids which are formed in the submerged soils, has the power of absorbing from such soil all or nearly all the alkalies, iron and sulphur found therein. This leaves the soil rich in alumina and silica, which are the leading constituents of the under-clays. The absorption of the iron oxides also causes these clays to assume that ashen gray color so characteristic of them.

Few, if any, fossils are found in these under-clays. The only things approaching them are the remains of the many long, thread-like roots, or underground stems (*Stigmaria*) of the larger plants (*Sigillarids* and *Lepidodendrids*) of the former coal flora.

The dark bituminous shales (Nos. 8 and 17 of the above typical section) are found lying directly upon several of the seams of coal, and constitute the so-called "black slate" of the miners. They vary much in thickness, and are usually very complex in their composition—being nothing more than the first mass of mud, impregnated with carbonaceous matter, which was deposited on the submerged vegetable remains in the old coal swamp. This mud was compressed and hardened into its present condition by the great mass of material afterward deposited upon it. Oftentimes these shales are very fissile, and cleave in large flat leaves almost as thin as paper. This is especially characteristic of the shales above coal V. (No. 17 of the section.) This "sheety shale" often appears to be a marine or sea deposit, containing generally fish scales and bones, sea inhabiting shells, etc., and frequently contains many concretionary boulders of pyrite, especially just at the top of and partially imbedded in the coal. Often these shales are so rich in bitumen that on drying by exposure to the air they show a decided tendency to bend or buckle.

The black shales are also often massive, with no visible signs of stratification. The amount of bituminous matter which they contain is, however, too great to allow them to be put to use as a clay material. Many of them contain a large percentage of oily matter which, if necessity should arise, could probably be distilled in paying quantities.

These overlying dark shales comprise the most noted fossil bearing horizon of the Coal Measures. They contain by far the greater number of those handsome impressions of the leaves of ferns and closely allied plants which are so characteristic a part of the fossil coal flora. Often, also, the great flattened stems of ancient trees occur many feet across and several scores of feet long; showing perfectly the scars where the fronds were attached. The remains of mollusks are, in some localities, also abundant in these shales—the lamellibranchs and gastropods being the chief groups which are represented.

The blue, drab and gray shales (Nos. 3, 6 and 12 of the section)

comprise the greater part of the Coal Measure rocks* of Indiana and, taken as a whole, are the most valuable clay deposits occurring in the State. They are not closely related to the strata found above or below them, and their thickness and composition varies exceedingly and is dependent entirely upon the character and source of those streams of water which flowed into the old lakes in which the shales were formed. If the stream was a large one and flowed for a long time with sufficient velocity to carry sediment far out into the deeper part of the lake, the bed of shale is thick, covers a large area, and is comparatively uniform throughout. On the other hand, if the stream was small and flowed slowly the shale bed is correspondingly thin, of small extent, and more apt to be varied in its composition. The kinds of rocks over which these ancient rivers flowed on their way to the lake determined the constituents of the sediments they brought down, and therefore the character and composition of the shales into which this sediment was afterward formed.

When freshly exposed these clay shales are usually hard and tough and more or less massive, requiring to be blasted or worked much as the seemingly harder rocks. As soon as exposed to the weather they soften and crumble into a mass of more or less plastic clay. This is commonly called "slacking," more properly "slaking." In general it may be said that the denser and more firmly cemented the shale mass is, the less easily will it slake under the action of the weather, and such a shale would also be harder to grind; that is, it will take longer grinding to break it up thoroughly. We therefore see that the condition of a weathered outcrop is a certain index to the way in which the shale will act in the grinding machines, it being more desirable, of course, to have a material that comminutes readily.

Some shales, when weathered, divide into thin flakes or leaves, when they are called "fissile shales." Others break up more or less into little cubes. Of these two the latter are generally more suitable for making clay wares. The very plastic shales, other things being equal, are best adapted for making stoneware and sewer pipe; those of moderate plasticity find their application in

*The term "rocks" in this report is used in its true sense, and signifies any material, whether hard or soft, which constitutes a portion of the crust of the earth. Thus, a bed of sand or clay is no less a "rock" than the hardest granite.

the manufacture of paving brick, while the lean or sandy ones are used mostly for dry pressed and common brick.

Based on their composition, the shales of the Coal Measures may be classified as follows:

(a) *Argillaceous or clayey shales*, in which clayey material (silicate of alumina) largely predominates. In color these are usually drab or blue, though yellow and buff shades are not of uncommon occurrence. They are almost free from "grit" and are often soft and unctuous or greasy to the touch. In the country they are known almost universally as "soapstones," but this term rightfully belongs to the mineral steatite or talc, a magnesian silicate which does not occur in Indiana. Sometimes, however, the shales are quite hard and tough, yielding but little to the pick and requiring the use of explosives for their removal. But whatever their character when first mined, upon exposure to air, rain and frost, they quickly disintegrate into soft, plastic, fine-grained clays of large commercial importance.

(b) *Siliceous or sandy shales* are those which have a large proportion of free silica or sand mixed with the clayey material. For the most part they are drab, buff or yellow in color, though sometimes gray or even bluish. Their value for manufacturing purposes depends largely upon the character of the sand particles found in them. Sometimes these particles are so minute as to be invisible to the naked eye, and the shale would pass as a clay shale unless carefully examined. The shales are then comparatively free from grit, and are scarcely inferior to the argillaceous shales in value. From this the grains of sand may become larger until they are plainly discernible to the sense of touch as well as sight. A more or less even mixture of sand and clay, that might with equal propriety be called a sandy shale or a shaly sandstone, is quite common in the Coal Measures. When of this character the deposits are of little economic importance. Oftentimes scales of mica are scattered abundantly among the particles of sand, and the shales are then known as "micaceous."

In the northern part of the Indiana coal field there is often found a peculiar combination of shale and sandstone known as "fake," "sand slate" and other less common names. It consists of thin, alternating layers of sandstone and shale, the layers often being like thin flakes, and giving a markedly banded appearance

to a fresh cross section of the stone. A weathered bluff of it closely resembles a bluff of fissile shale, as the shaly flakes tend to weather out, leaving the thin projecting flakes of white sandstone, but with a coating of the dark shale which makes them appear as shale until broken across. In the block coal field this rock often immediately overlies the coal, making the roof. This formation, wherever found, contains too much grit for manufacturing purposes.

(c) *Calcareous or Limey Shales*.—These are much less common in the Indiana Coal Measures than either of the two preceding. They contain a large percentage of carbonate of lime (CaCO_3) commingled with the clayey material. Such shales may be readily known by their light grayish color and the readiness with which they effervesce with muriatic acid. Where found they are usually in close connection (either above or below) with a stratum of limestone. Oftentimes they contain remains of the shells of marine or brackish waters. Such limey shales are, by the miners, usually known as “clod” or “marl.” It may also usually be noticed that the line of contact between this shale and the limestone is very irregular; indeed, in some places the limestone loses entirely the character of a layer and appears as lenticular masses or boulders in the structureless shale or “clod.” In such cases it is evident that the clayey shale is only the residuum left by the decomposition of the limestone. In some cases this entirely replaces the limestone, and should then be recognized as of the same horizon. Surrounded as they are by so much material of better quality, these calcareous shales of the Coal Measures are of little commercial importance. In some of the older formations (Silurian, Devonian, etc.) where good clays are less common, they may be utilized in making bricks when the percentage of lime is not too great and is disseminated evenly throughout the shale.

In some localities sharp lines of division separate the above named varieties of shales; but generally they merge so gradually into one another that it is often difficult to say where the one ends and the other begins. Thus, by the gradual addition of fine particles of sand the argillaceous shales pass into siliceous; these, by the addition of coarser particles, into shaly sandstones, and finally into hard and durable sand rocks.

Loess Clays of the Coal Measures.—It was noted while gather-

ing the data for this report that the loess clays mentioned on page 23 covered a large portion of the uplands in the following counties: Sullivan, Knox, Daviess, Dubois, Pike, Gibson, Posey, Vanderburgh, Warrick and Spencer. Over this area, which corresponds closely to that of the Carboniferous area south of Vigo and Clay counties, these loess clays are the ones commonly used for ordinary brick or drain tile.

Along the borders of the immediate valleys or flood plains of the Wabash and White rivers the common loess is, in many localities, replaced by a narrow strip of "marl-loess," which is a white, gray or yellowish silt containing a high percentage of carbonate of lime. In places it is delicately stratified and contains numerous fossil shells. This marl-loess occurs from the high water level up to 120 feet above, but seldom, if ever, is found above the 500 foot level of the region. It forms the immediate face of many of the bluffs, from northern Knox County, to Grand Chain, below New Harmony. On account of its high percentage of lime, it is not suitable for clay working purposes.

The common loess, with which we have more particularly to deal, is not confined to any one horizon, but occurs at all elevations from the level of the river bottoms to the crests of the highest hills. Above a certain altitude, which detailed observation has shown to be approximately 500 feet above tide (120 feet above the river), it constitutes the only silt noted. Though differentiated only with some difficulty from the marl-loess, a thin coating of the common type usually appears to begin within a quarter of a mile of the edge of the immediate river valley, and increases gradually in thickness for several miles to the east, probably reaching a maximum of 15 feet or more at a distance of six or seven miles, beyond which it slowly decreases until, at a distance of 35 or 40 miles it has a thickness of only two or three feet, or possibly even less.*

As to the source of the two forms of loess, Messrs. Fuller & Clapp,† who have given it special study, conclude "that the *marl-loess* is of aqueous origin, consisting of silts deposited in former expansions of the White and Wabash rivers, the materials being brought down from the margin of the Iowan ice sheet by the

*Fuller & Clapp.—Bull. Geol. Soc. America, XIV, 1903, 156.

†Loc. Cit. p. 172.

Wabash River. On the other hand, the presence of the common loess at all altitudes up to the highest the region affords (640 feet), the absence of fossils, the absence of stratification, and the lack of definite topographic forms all point to its accumulation through an agency other than that which governed the deposition of the marl-loess. This agency is believed to have been the winds. The fact that the common loess is sometimes entirely absent along the immediate tops of the bluffs facing the Wabash on the east side, but begins to appear within a short distance, and for several miles rapidly increases in thickness, and then slowly but persistently decreases, suggests that the marl-loess along the Wabash and White rivers was the source of the material. The agency which brought about the accumulation of common loess we believe to have been the westerly winds blowing across the marl-loess beds which were exposed during periodic fluctuations of the water level."

SECTION. III. THE CLAYS OF INDIANA BY COUNTIES.

In the gathering of the data on which this report is based, it was impossible, owing to a lack of time, to examine all the deposits of clay in each county visited. In general, only those more important deposits within five miles of a railway, either in operation or contemplated, were investigated. While other deposits of good quality and large size undoubtedly exist at a greater distance from the railways, they are at present of little or no value. *Transportation facilities* form one of the principal factors in determining the value of any clay deposit. It will not pay to haul any known Indiana clay in wagons a distance of more than five miles. It will not pay to haul it at all, provided a railway switch can be put in for a reasonable sum. Competition in the making of clay products is at present too great and clay deposits are too common to justify such hauling.

The prospective manufacturer in locating a site for any future clay industry, if he be wise, will always take into consideration the following factors: (a) Quality and size of the deposit of raw material or clay; (b) Transportation facilities; (c) Fuel facilities; (d) Water facilities. These are named in the order of their importance. If he has a large deposit of clay suitable for making the wares which he desires to produce; located in easy reaching distance of one or more railways, and where fuel and water can be easily obtained, he can compete with any factory of a similar kind on earth. Under the proper management, his business from the beginning will be an assured success. In general it may be said that a good clay deposit alone will not attract capital unless the other facilities are at hand or "in sight." Cheap fuel is a necessity and, in the coal bearing counties, often immediately underlies the clay. A large amount of water is used daily in a clay plant of any size, and a never failing source of it is therefore a necessity. Railways are necessary to carry away the finished product and also to bring in the fuel, provided the latter is not found on the ground. With any one of the above named factors absent or difficult to obtain, the prospective manufacturer will have a difficult road to travel.

There are of course a number of clay factories in Indiana which bring in all raw materials and all fuel from a distance, but they

make only the higher grades of clay products, such as porcelain wares, encaustic tiles, glass pots, etc. Each of their wares is made of four to six different clays and other ingredients, most of which do not occur in the State. The excellence of transportation facilities and cheapness of fuel were probably the inducements which led to the present locations of such factories.

Specimens of almost all of the deposits of clay mentioned on the following pages, as well as many samples of their burned products, are in the collection belonging to the State, and all persons interested in clays or clay manufacturing are cordially invited to call at the office of the State Geologist and examine them.

I desire at this place to express my indebtedness to the many persons residing in the counties visited, who aided me in my researches. The number is too great to allow of individual mention. Almost everywhere I was treated most courteously and afforded every facility for securing the knowledge which I sought.

I. COUNTIES OF THE CARBONIFEROUS AREA.

FOUNTAIN COUNTY.

This county is near the northern extremity of the Carboniferous area of the State. It lies south and east of Warren; east of the northern part of Vermillion; north of Parke, and west of Montgomery and Tippecanoe counties. The general shape is triangular, as the Wabash River forms its northern and western boundaries. The maximum length of the county from north to south is $28\frac{1}{2}$ miles, and the maximum width from east to west, $18\frac{1}{2}$ miles; its area being 383 square miles.

The geological epochs represented in the county are three; the Knobstone of the Lower Carboniferous, and the Mansfield sandstone and the Coal Measures of the Carboniferous Period. The rocks of the first named epoch outcrop on either side of the Wabash River from the Tippecanoe County line to a point three miles below Attica, and also form the surface of the greater part of the eastern third of the county north of the Clover Leaf Railway. The Mansfield sandstone forms an irregular strip three to seven miles in width, which enters the county at its southeastern corner and extends in a northwesterly direction to the Wabash River at Fountain. A long lobe or tongue of the same rocks forms the sur-

face from Fountain in a northeasterly direction toward Attica. The remainder of the county—about 160 square miles of its southwestern portion—is underlain by the Coal Measures.

The general character of the county is that of a gently rolling plain, with a slight inclination to the south and west. In the northeastern part a high gravel ridge starts gradually and runs parallel with the river, sometimes attaining a height of 250 feet above the river, and 100 feet above the surrounding region. Two or three miles southeast of this is another less conspicuous parallel ridge of gravel. Along the immediate valley of the Wabash the bounding bluffs and ravines make some rather broken country, while the tributaries of Sugar Creek cut up the southeastern corner into a rugged region.

As already noted, the Wabash River flows along the northern and western border of the county, and in the northern half the drainage is principally by the Big and Little Shawnee creeks into that stream. The central part of the county is drained by Coal Creek, with its tributaries, Turkey Run, Dry Run, East Fork, Prairie Creek and Graham Creek. Wabash Mill Creek and Sugar Mill Creek drain the southern portion.

The entire surface of the county is covered with a deposit of glacial drift—soil, gravel, sand and clay—in some places attaining a thickness of more than 100 feet. On this account, it is only where coal shafts or bores have been put down, or where the above named streams have eroded ravines and gulches, that the character and value of the underlying strata can be ascertained. The thick deposits of shales, both Knobstone and Carboniferous, which underlie a large portion of the county, can be most readily secured at their outcrops along these streams; while in the Coal Measures of the southwestern part the valuable under-clays are located.

The county is well supplied with transportation facilities. The C. & E. I. Railway across it from north to south; the Peoria Division of the C., C., C. & St. L. Railway crosses from east to west; the T., St. L. & K. C. Railway crosses from northeast to southwest; while the Wabash follows the northern boundary down to Attica, and has a spur running from that city to Covington, the county seat.

Townships 21 and 22 North, Ranges 6 and 7 West.

a. *The Knobstone Shales.*—These shales were examined only in the vicinity of Attica and northeast of that city. Perhaps the best and most available outcrop for commercial use occurs on what is known as the Ice House and adjoining tracts in the southwest quarter of section 32 (22 N., 7 W.); three-fourths of a mile northeast of the center of Attica and 300 feet west of the Wabash Railway. The Knobstone shale here forms the bed of the old Wabash and Erie canal for at least a quarter of a mile, and was exposed when the canal was excavated. A section on the side of the canal near the ice house showed as follows:

Section of Knobstone Shale near Attica, Ind.

	<i>Feet.</i>
1. Soil and surface clay.....	3
2. Shaly sandstone	2
3. Bluish gray shale.....	8+

Where exposed, the shale at this point had weathered into a soft plastic clay of a light gray color, which would, without doubt, be found suitable for paving, pressed front and ordinary brick. Samples from here had also been made into flowerpots by F. S. Lowrey of Roseville, Ohio, who reported on them as follows: "I found the flowerpots made from the clay near the ice house to be very satisfactory, indeed. I reserved two or three of them and gave them a good test, finding them to be perfect in every way, and I assure you they would be very salable goods on the market. As to the shipping facilities, none better could be expected."

Just across the railway from the ice house an exposure of the shale was made after my visit, which showed nine feet of the blue-gray Knobstone shale overlain by six feet of lighter, partly decomposed shale, and yellow clay. Samples of the hard, unweathered shale from this exposure were analyzed by Dr. Robert Lyons for this report, the composition being found to be as follows:

Analysis of Knobstone Shale from near Ice House, Attica, Ind.

Silica (SiO ₂)	68.14
Titanium (TiO ₂)	1.38
Alumina (Al ₂ O ₃)	16.03
Combined water	3.86

Clay base and sand.....	89.41
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Ferric oxide (Fe_2O_3).....	4.54
Lime (CaO)	0.47
Magnesia (MgO)	0.27
Soda (Na_2O)	1.50
Potash (K_2O)	3.80
<hr/>	
Fluxes	10.58
<hr/>	
Total	99.99*

The above analysis shows the unweathered shale to be rather high in silica, and a little below the average commercial shale in fluxes. The quantity of fluxes found is, however, sufficient to fully vitrify the material. To make sewer pipe, hollow brick or other product with a thin body wall, the shale would probably have to be weathered for some time or else mixed with about one-fourth of a more plastic clay such as the under-clays of the Coal Measures south of Attica.

That the shale from this point can be made into vitrified paving brick or pressed front brick of good quality has been proven by practical tests made by the Chicago Brick Machine Company, who reported on it as follows: "This shale will make elegant dry press face brick or if worked by the stiff mud process would make an excellent paving brick. These brick, as you will see, have unusual weight and a very beautiful color, sharp and strong edges and corners and a normal shrinkage. * * * We would not hesitate to guarantee our machinery to the fullest extent to produce first-class brick from these materials by either process."

Knobstone shale of practically the same chemical composition is being made into one of the best paving bricks in Indiana at Crawfordsville, Montgomery County. Taking into consideration the railway facilities present at Attica, together with cheap fuel and abundant water, there is no reason why a large brick factory should not prove a success if located on the site of this shale deposit.

On the Shippo farm, west half of the southwest quarter of section 34 (22 north, 7 west), one and a half miles northeast of Attica, the bluish gray Knobstone shale outcrops with an exposure of 22 feet. It is found in a ravine less than one-fourth of a mile east of the main line of the Wabash Railway. The shale is over-

*For composition of "clay substance," "rational analysis," etc., see "Table of analyses of Knobstone shales," in a later section.

lain with from three to six feet of soil and yellow clay, and at intervals throughout the exposure are thin seams of sandstone two inches to one foot thick, there being three such layers in the 22 feet exposed. The shale weathers into a fine-grained, very plastic clay, suitable for pressed front or vitrified brick.

Farther northeast, at the point in section 19 (22 north, 6 west), at which the wagon road crosses the stream known as "Turkey Run," is a bed of similar shale, exposed to a thickness of 30 feet. This is but one-third of a mile south of the Wabash Railway and, like the preceding, may be gotten by easy stripping.

On the land of Edward Sylvester, in the southeast quarter of section 20 (22 north, 6 west), seven miles northeast of Attica and two and a half miles northeast of Riverside, the same bluish gray Knobstone shale outcrops in a ravine to a thickness of 20 or more feet, and over a wide area has but a thin stripping. Where weathered it is very plastic and seemingly of good quality for manufacturing purposes. The point of outcrop is about one-half mile south of the Wabash Railway. There are doubtless many other localities in this part of the county at which the Knobstone shales come near enough the surface to be easily obtained; but the above mentioned were all that were examined by the writer.

South of Attica but one outcrop of Knobstone shale was visited. This was on the land of Dr. Alexander Whitehall and other parties, about two miles west of Rob Roy, in the southeast quarter of section 23 and the southwest quarter of section 24 (21 north, 8 west). Here, for a distance of nearly half a mile, Shawnee Creek has eroded a bed through the overlying Mansfield sandstone and a thick stratum of blue argillaceous shale. Thirty-two feet are exposed at the point mentioned, which is about one mile east of where the Attica and Covington Railroad crosses the stream. The greater part of this deposit will be found suitable for vitrified products, but a stripping of about five feet of clay and sandstone would have to be removed. The shale is softer, contains less silica and is more easily weathered and ground than the Knobstone shales of the northern part of the county.

b. Carboniferous Shales and Under-Clays.—In the area noted above as being covered by the Mansfield sandstone there are, in Fountain County, a number of deposits of shale and clay suitable for manufacturing purposes. At the quarry of the Silica Plant,

operated by the Western Silica Company on the south side of Shawnee Creek, about one mile west of Rob Roy, the following section is exposed:

Section at Quarry of Western Silica Company.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil and surface clay.....	2	0
2. Black sheety bituminous shale.....	5	0
3. Light gray sandstone with streaks of iron oxide	11-16	0
4. Coal I	0	8-10
5. Bone coal or "black jack".....		6-8
6. Under-clay	6	4

The black shale (No. 2) contains too much bituminous matter to be used for clay products, but the under-clay, No. 6, is of good quality, and could be used for stoneware and vitrified products, provided enough of it could be secured from beneath the heavy stripping. On the north side of the stream, between the office and the main plant of the Silica Co., and just below the switch of the C. & E. I. Railway, occurs a deposit of soft, light blue to buff argillaceous shale, ten feet or more in thickness, overlain by three to five feet of surface clay. This shale appears in every way suited for vitrified wares.

On the George Nave farm, northwest of northwest of 19 (21 north, 7 west), coal has been mined for local use for a number of years. A section at a point of the new drift entry showed as follows:

Section on the Nave Farm, Northwest of Rob Roy.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil and surface clay.....	2	0
2. Blue argillaceous shale.....	2-6	0
3. Black bituminous shale and bone coal.....	1	2
4. Coal	1	10
5. Bone coal	1	0
6. Bluish shaly under-clay.....	5+	0

Ten yards west of the new drift the section showed only shale extending 12 feet below drainage, except a three-inch bed of sandstone. Shale No. 2 and under-clay No. 6 are both of good quality, and combined or separately could be used for a number of different classes of clay products.

Township 20 North, Ranges 7 and 8 West.

On Rattlesnake tributary to Bear Creek, southeast quarter of section 4 (20 north, 8 west), Mr. George Galloway some years ago sunk a shaft in search of coal, a section of which shows as follows:

Section of Galloway Shaft No. 1.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil	3	0
2. Black sandstone	4	0
3. Dark, bituminous shale	1	10
4. Coal	0	2
5. Under-clay merging into sandstone.....	3	8
6. Light gray shale.....	10	0

The under-clay (No. 5) is light gray and very siliceous. It is formed of a peculiar mixture of fire-clay and sandstone called "Gannister rock." If thoroughly tested it will doubtless be found suitable for the lining of Bessemer and other steel converters. Mr. Galloway states that it was tested in a fire brick furnace at Montezuma. The test resulted in the melting down of the Montezuma fire brick, while the Gannister did not change form but became lighter in color.

The shale (No. 6) when weathered, is very plastic and can be made into stoneware. Its partial analysis, according to Kramer, is as follows:

Analysis of Shale from Land of George Galloway, Fountain Indiana.

Silica (total)	73.20
Alumina	13.38
Clay base and sand.....	86.58
Magnesia	1.01
Lime .....	.97
Ferric oxide	2.19
Fluxes	4.17
Moisture and volatile.....	9.25

A mixture of this clay with a clay from an adjoining farm was tested in a roofing tile factory at Covington, about 1886, but according to Mr. Donaldson, one of the proprietors, it did not give satisfaction as it cracked badly when burned hard enough to withstand the action of frost. It is said to be one of the best modeling clays in the country.

In the autumn of 1903 a new shaft was sunk by Mr. Galloway, 30 rods southeast of the old, in the lowlands of Rattlesnake Creek, which exposed the following strata:

Section of Galloway Shaft No. 2.

	<i>Feet.</i>
1. Soil and surface clay.....	2
2. White siliceous clay.....	10
3. Bituminous shale	4
4. Light gray siliceous shale.....	8+

No. 2 of this section probably corresponds to the Gannister (No. 5) of the preceding. Under the lens no difference in composition or structure can be detected, but it appears as a very hard, fine-grained sandstone. A partial analysis of a sample of it was made by State Chemist H. A. Huston, of Purdue University, who reported on it as follows:

Analysis of White Clay from Galloway Shaft No. 2.

	<i>Per Cent.</i>
Silica (SiO ₂)	93.79
Alumina and iron oxide (Al ₂ O ₃ +FeO).....	4.23
Lime (CaO) .....	.32

"There is very little iron in the material which, in composition, stands between the Dinas and the Eisenburg clays, both of which are noted for being very infusible and for having very little shrinkage."* While the so-called clay is undoubtedly of a very high refractory character, some difficulty might be experienced in causing it to bond after grinding. This could be readily overcome by mixing with it a small percentage of a more plastic clay from the Coal Measures. So mixed, there is little doubt but that it would make a class of high grade refractory wares, such as furnace linings, saggars, retorts, etc. Its chemical composition and structure are of such a character as to fully justify careful practical tests of the clay for such purposes.

No. 4 of the section weathers into a very soft, whitish, plastic clay, which has every appearance of being suitable for stoneware, sewer pipe and kindred products. It, however, contains in places thin layers bearing numerous dark brown specks of iron silicate or "pin ore," which would depreciate its value unless they could be separated by washing.

*The Dinas clay is found in England and is used for roofs of furnaces. The Eisenburg clay is a very refractory German product.

Along the bottoms of Coal Creek, on the land of Minnick & Hoagland, northeast quarter of section 19 (20 north, 7 west), one-half mile southeast of Stone Bluff, is an outcrop of a light gray potters' clay of a superior quality. It is wholly free from grit and has the greasy feel which the better grades of such clays possess. At the point of outcrop it is overlain with soil and yellow clay six feet in thickness; the stratum of clay being exposed to a depth of five feet, but its total thickness is as yet undetermined. In the bluffs near by it is found beneath twenty feet of soil and sandstone, and forms the under-clay of a vein of coal two feet six inches thick. An analysis of this clay was made for the 1895 clay report by Dr. R. E. Lyons. It is here given in connection (for comparison) with an analysis of the famous Akron, Ohio, stoneware clays.*

Analyses of Stoneware Clays from Stone Bluff, Ind., and Akron, Ohio.

	<i>Stone Bluff, Ind.</i>	<i>Akron, Ohio.</i>
Silica (SiO_2)	68.46	68.13
Titanium oxide (TiO_2).....	1.49
Alumina (Al_2O_3)	16.08	20.80
Water combined	7.04	5.72
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Clay base and sand.....	93.07	94.65
Ferric oxide (Fe_2O_3).....	1.92	1.20
Ferrous oxide (FeO).....	.06
Lime (CaO)99	.42
Magnesia (MgO)05	.37
Potash (K_2O)	1.31	2.28
Soda (Na_2O)	2.40	.27
<hr/>		
Fluxes	6.73	4.54
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Total	99.80	99.19

The C. & E. I. Railway passes within eighty rods of this deposit. The clay is found over an extensive area north and northwest, having been exposed in wells on the lands of William Mallett and Albert Boord.

On the land of Frank Landers, northwest quarter of section 19 (20 N., 7 W.), one-half mile west of Stone Bluff, the same stratum outcrops in several places. It is here known to be eight

*The analysis of the Akron clays represents an average of several samples selected from the ground clay used in several plants and then mixed.

feet thick, and in some places is overlain with a thin vein of coal. Mr. Landers had a sample of the clay analyzed by Dr. Lyons with the following results:

Analysis of Under-Clay from Land of Frank Landers, Stone Bluff, Ind.

Silica (SiO_2)	67.82
Titanium oxide (TiO_2).....	1.10
Alumina (Al_2O_3)	13.60
Water combined	9.72
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Clay base and sand.....	92.24
Ferric oxide (Fe_2O_3).....	4.04
Ferrous oxide (FeO).....	.45
Lime (CaO)57
Magnesia (MgO)44
Potash (K_2O)	1.68
Soda (Na_2O)	1.18
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Fluxes	8.36
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Total	100.60

The analysis proves the chemical fitness of the clay for making sewer pipe, hollow brick, drain tile and kindred products.

Township 19 North, Ranges 7 and 8 and Part of 9 West.

The Hillsboro Pressed Brick Company for some time made dry pressed front brick from a surface stratum of siliceous ochery clay, located just south of Hillsboro, near the middle of section 12 (19 north, 7 west). The deposit is a remarkably pure one, to be found on the surface in the drift region, and resembles closely the residual surface clays of southern Indiana. The works of the company were located on a tract of low ground near the bed of Coal Creek, and the clay was secured from the top of the adjoining bluff, the face of which discloses the following section:

Section of Bluff at Hillsboro, Ind.

	<i>Feet.</i>
1. Soil and yellow ochery clay.....	9
2. Drab arenaceous shale	3
3. Reddish sandstone	12
4. Gray arenaceous shale (micaceous).....	3
5. Sandstone .....	..

The dry pressed brick made from the clay (No. 1) were a handsome shade of dark red, but were much more friable than those made by other companies from argillaceous shale. As a consequence, too many of them were broken in handling, and the company finally abandoned the enterprise. For a time the two shales (Nos. 2 and 4) were mixed and burned into a fair quality of buff, pressed brick. They were found to be too highly siliceous for vitrified products.

In the immediate vicinity of Veedersburg are found the best known shale deposits of Fountain County. Before the great value of shales for making vitrified products was fully understood, the Wabash Paying Brick Company,* now the largest concern of the kind in the State, had located a plant one-half mile southwest of Veedersburg, southeast quarter of section 12 (19 north, 8 west), close to the lines of the T., St. L. & K. C. and C. & E. I. railways. Here they began making pavers from a fire-clay which outcropped in a hill to the west. This clay gradually merged into sandstone as it passed back under the hill, until finally it became too siliceous for use.

The company had meanwhile experimented with shales, and finding them highly suitable for their purpose, began procuring them from two different places. Their main supply is now secured from the land of Boord Bros., near the middle of section 13 (19 north, 8 west), about one mile southwest of their plant. Here, along the south bluffs of Coal Creek, is located one of the largest and purest deposits of Carboniferous shales in the State. In June, 1904, the pit had been worked to a depth of 50 feet. Everything from the grass roots down was being used, except a band of iron carbonate three to five inches thick, which occurs eight to ten feet below the surface. A section of the pit showed as follows:

Section of Shale Pit South of Veedersburg; Worked by Wabash Clay Co.

	<i>Feet.</i>	<i>Inches.</i>
1. Surface soil and yellow clay.....	2	8
2. Blue argillaceous shale, upper 3 feet discolored by leachings from the soil.....	35	0
3. Coarse grained arenaceous shale.....	0	3
4. Blue shale, same as No. 2; bottom concealed.....	15	0

*For a description of the factory of this company and statistical information regarding it, see under the section "The Clay Industries of Indiana."



Shale Bluff on land of Boord Bros., one and a half miles southwest of Veedersburg, Fountain County. Shale used in the making of Paving Block by the Wabash Clay Co.

The shale is rather soft, dark blue in color and of very fine texture. The deposit is very homogeneous, being almost free from the concretions of iron carbonate so commonly found in such strata. The bluff of shale is exposed for one-fourth mile down the creek from the present pit, and extends over a wide area to the south and southwest. The Wabash Clay Company use 125 tons of clay a day, two-thirds of which is hauled in wagons from this pit to their plant. They pay a royalty of 3 cents per ton for the shale, and 20 cents a ton for hauling to the factory.

About one-third of the raw material used by the Wabash Clay Company is gotten from the Culver farm, one mile north of Veedersburg on the southwest quarter of section 31 (20 north, 7 west). Here a shale bank has been opened alongside a switch of the C. & E. I. Railway, the material being hauled in cars to the factory at a cost of $22\frac{1}{2}$ cents per ton. A section of this pit shows as follows:

Section at Clay Pit on Culver Farm, One Mile North of Veedersburg.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil and drift clay.....	1—4	0
2. Outcrop coal V?.....	0	0—6
3. Grayish plastic under-clay.....	3	0
4. Light gray clay shale, the upper 6 to 10 feet with reddish streaks.....	16	2
5. Coal IV	2	6
6. Bone coal	1	0
7. Drab under-clay	5	4

Of these, all above coal IV (No. 5 of the section), except about one foot of soil, are mingled in the proportions in which they occur in the bank. The general dip of the strata is to the north. The under-clay, No. 7, is a plastic clay which, judging from its appearance, will make stoneware, hollow brick, etc. It could be mixed with the shale in the proportions of one part to four, to make paving brick, but up to the present has not been used for that purpose.

From a mixture of this shale from the Culver farm with that from the bank south of their plant, the "Poston Block," so many of which have been used for paving purposes in Indiana and adjoining states during the past decade, are made by the Wabash

Clay Company. An analysis of a sample, composed of a mixture from the inside of three unburned blocks shows the following composition of the material entering into their structure.*

Analysis of a Mixture of Material Used in Making Paving Block by the Wabash Clay Company.

Silica (SiO_2)	59.55
Titanium oxide (TiO_2).....	1.00
Alumina (Al_2O_3)	16.21
Water combined	5.62
<hr/>	
Clay base and sand.....	82.38
Ferric oxide (Fe_2O_3).....	2.18
Ferrous oxide (FeO)	7.13
Lime (CaO}) .....	.75
Magnesia (MgO)	1.58
Potash (K_2O)	2.81
Soda (Na_2O}) .....	.28
<hr/>	
Fluxes	14.73
Carbon dioxide (CO_2).....	3.15
<hr/>	
Total	100.26

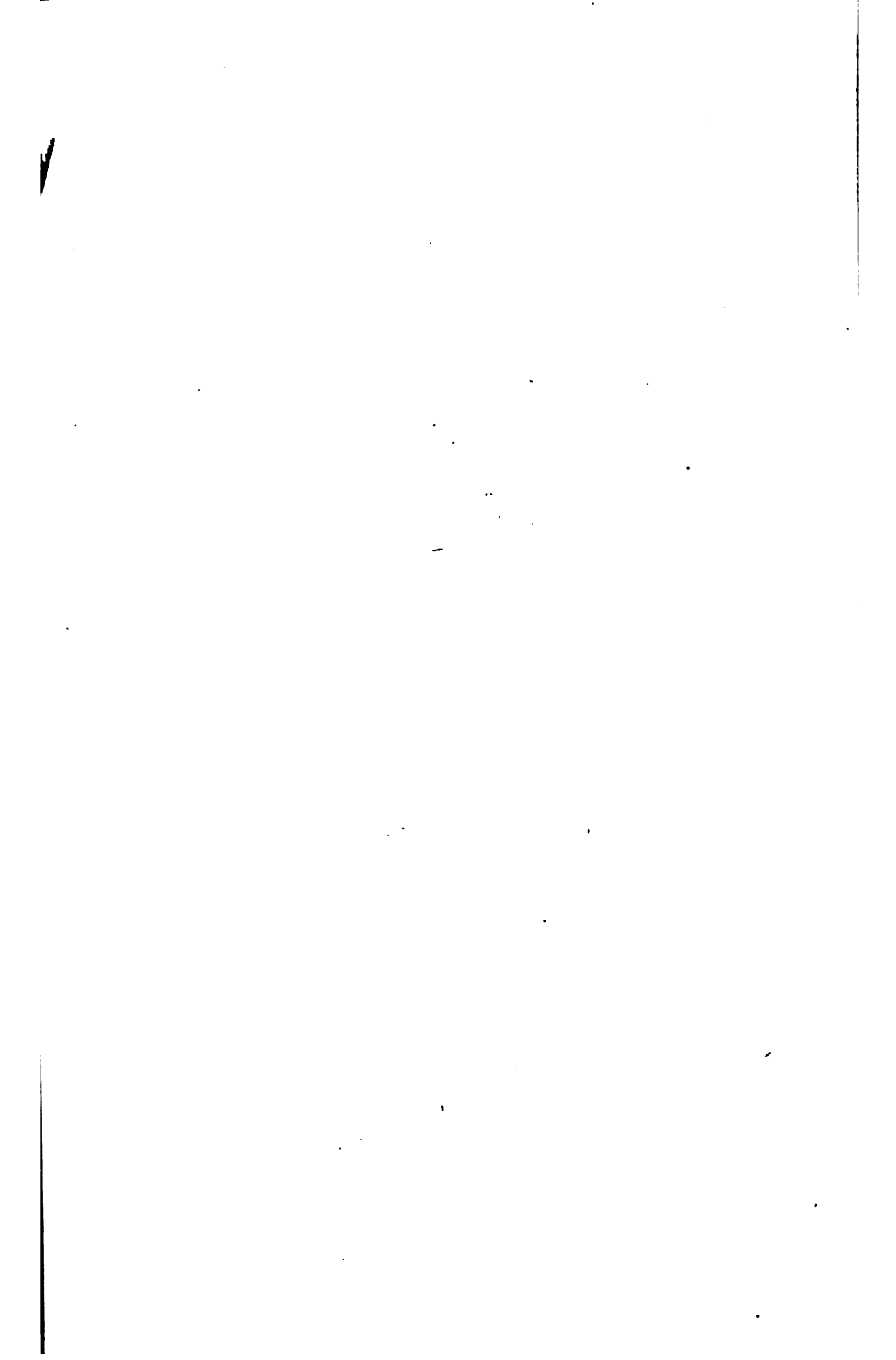
According to Prof. Edward Orton,† the average composition of the shales used by ten of the leading paving brick and sewer pipe factories of Ohio shows—

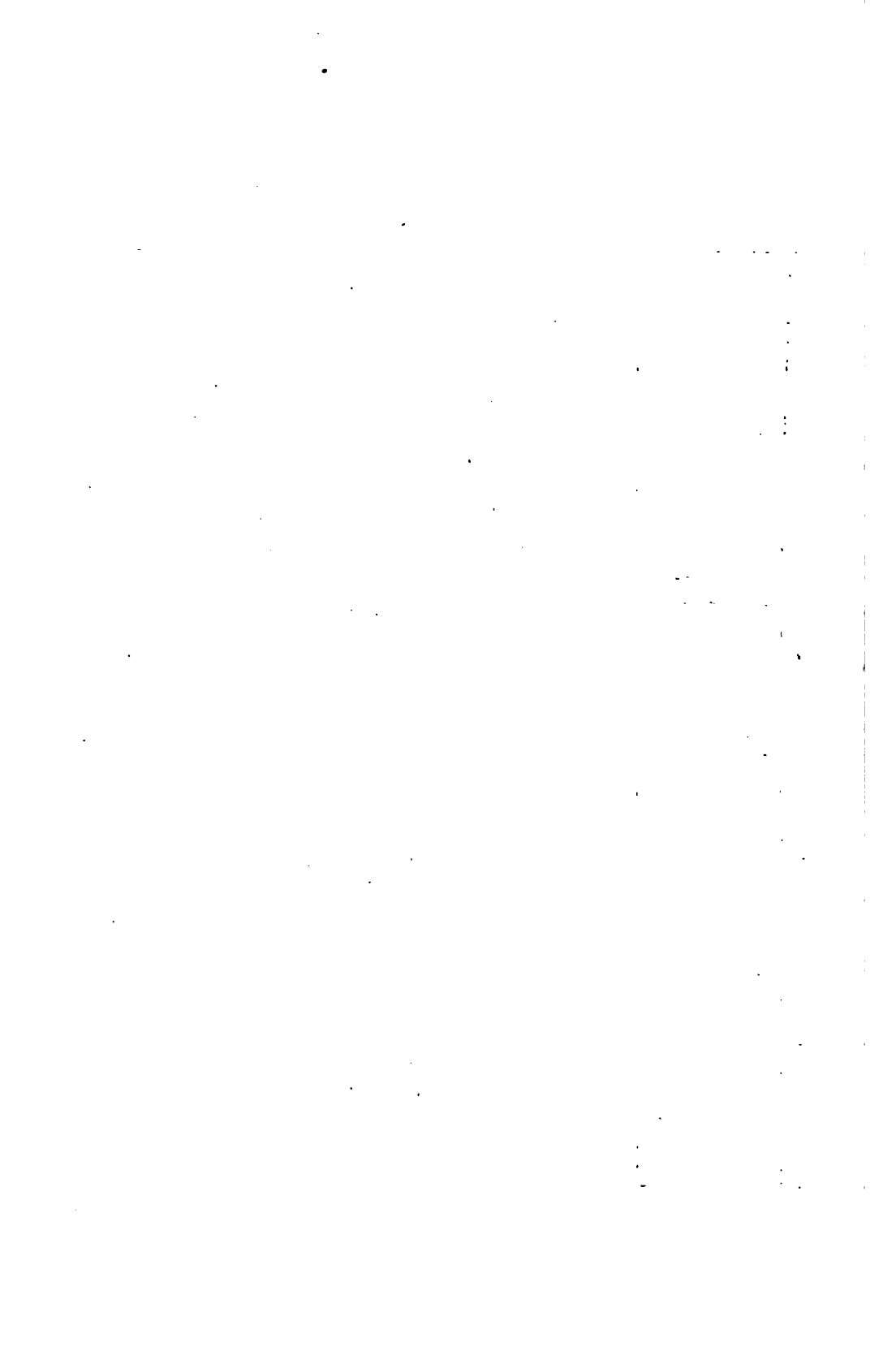
Clay base and sand.....	84.78
Fluxes	13.22

with a variation in the ten of only 4.1 per cent. in clay and sand, and 6.04 per cent. in fluxing ingredients. Taking this as a future standard of comparison for the composition of Indiana shales suitable for vitrified products, we find that the material used by the Wabash Clay Company shows the presence of 2.40 per cent. less of refractory material, and 1.51 per cent. more of the fluxes than the standard. This is probably due to a large admixture of the surface soil and clay from the pit north of Veedersburg. Nevertheless, the mixed materials showing the above composition stand up well until thoroughly vitrified, and produce a strong and durable paving block.

*W. A. Noyes, chemist. For rational analysis, etc., see under "Table of Analyses of Carboniferous Shales," in a later section.

†"The Clay-Working Industries of Ohio," in Geol. Surv. Ohio, VII, 1893, 134.





One-third of a mile west of the Big Four Railway station at Veedersburg, and just south of the main line of that railway, on the southwest quarter of section 1 (19 north, 8 west), the Veedersburg Clay Company* finished, in 1904, a modern plant for the making of vitrified brick and similar products. At the time of my visit in June, 1904, their clay pit, 75 feet south of the plant, had just been opened. A shaft had also been started beneath one corner of their plant from which it was expected to mine coal IV for fuel, and also to secure shale and under-clay for future use. A section of the pit as far as exposed showed as follows:

Section of Pit of Veedersburg Clay Company, Veedersburg, Ind.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil and yellow clay, stripped.....	2	0
2. Tough yellow clay with an occasional nodule of kidney iron ore.....	3	0
3. Shale, light gray siliceous.....	8	0
4. Black bituminous shale	4	0
5. Coal V?	1	10
6. Gray sandy under-clay.....	2	0
7. Light gray siliceous shale.....	7+	0

Of this section, Nos. 2 and 3 were being mixed and used for the making of bricks for the building of new kilns. An attempt was made to make vitrified brick from the shale No. 3, but after a number of trials it was found that the shale was too high in silica to vitrify. The plant was therefore closed down on October 1st, until such a time as the new shaft could be completed or a railway switch put in to the shale deposit on the Marshall land, to be hereafter described.

On the north side of the Big Four Railway, in the same quarter section, and just north of the factory of the Veedersburg Clay Company, is an old abandoned coal shaft, through which coal was mined for a number of years. A section of this shaft, as given by Ashley,† is as follows:

*For equipment of plant, see under "Clay-Working Industries of Indiana."

†Twenty-third Ann. Rep. Dep. Geol. Nat. Res. Ind., 1898, 242.

Section of Shusler Coal Shaft, Veedersburg, Ind.

	<i>Feet.</i>	<i>Inches.</i>
1. Gravel	20	0
2. Fire-clay and shale.....	7	0
3. Sandstone with shale partings.....	30?	0
4. Coal V	1	8
5. Light drab fire-clay.....	7	0
6. Drab shale with plant remains.....	10	0
7. Coal IV?	4	2
8. Light gray sandy fire-clay.....	9	0

North of Coal Creek, south and southwest of Veedersburg, the surface rocks seem to be largely composed of heavy ledges of sandstone, but south of Coal Creek and southeast of Veedersburg, a thick stratum of blue shale seems to have replaced the sandstone.

One and a half miles southeast of Veedersburg, on the land of Miles Marshall, northwest quarter of section 17 (19 north, 7 west), a bold bluff of the same stratum of blue shale as that worked at the main pit of the Wabash Clay Company on the Boord land, rises abruptly from the margin of the north side of Coal Creek. The top of the bluff is covered with from three to six feet of gravel suitable for road material. The shale then sets in, and is exposed for 38 feet to the water, beneath which the foot of the bluff is hidden. It is reported that a drill hole sunk 43 feet below low water level in Coal Creek did not reach the bottom of the shale stratum. This shale bluff is very uniform in color and structure throughout the exposure, the only impurity noticeable being two thin layers of ironstone near the center. Negotiations are now under way to construct a switch of the C., C., C. & St. L. Railway to this bluff for the purpose of using the shale for vitrified products.

One-fourth of a mile nearer Veedersburg, on the land of William Dice, southwest quarter of section 8 (19 north, 7 west), the same shale is found in abundance, and can be easily secured by removing three feet of surface stripping. There is also a conspicuous shale bluff on the south side of Coal Creek near the middle of section 17 (19 north, 7 west), and another at the mouth of Clifty Creek in section 15 (19 north, 7 west). At the latter place the shale outcrop is 30 feet thick, and rests unconformably against a sandstone at the eastern end of the bluff.



Shale Bluff of Coal Creek, on land of Miles Marshall, one and a half miles southeast of Veedersburg, Fountain County.

In a ravine a short distance southeast of the shale bluff belonging to Mr. Marshall, is an outcrop, three feet in thickness, of a peculiar surface drift clay. It is a light brown in color, and, when wet, one of the most tenacious materials I have found among Indiana clays. When dry it becomes exceedingly hard, and "sets" like plaster of Paris. It has all the properties of a most excellent modeling clay.

Numerous other deposits of clay which are suitable for manufacturing purposes doubtless occur in the vicinity of Veedersburg, but the above are all that can be noted in this connection. Three railways pass through the town, connecting it directly with some of the more important commercial centers of the United States. With such superior facilities for transportation, with an abundance of coal within 25 miles, and with an unlimited supply of excellent shales in the immediate neighborhood, nothing but a lack of energy on the part of its people will prevent the town from becoming the seat of important clay industries.

As noted on a preceding page, about 160 square miles of the southwestern portion of Fountain County, except a narrow area along the Wabash River, is overlain by the Coal Measure rocks. The coal veins found over this area are IV and V. Coal V is usually overlain with sandstone, with often black, sheety shale lying directly on the coal, but between it and IV there often occurs a thick deposit of workable shale. The under-clay beneath V is usually everywhere of good quality, but that beneath IV is more apt to be very siliceous, approaching a sandstone in character.

One mile south of Covington, on the land of the Hon. Enos Nebeker, south half of the northwest quarter of section 1 (19 north, 9 west), the following strata are exposed on a hillside facing the north:

Section on Nebeker Land, South of Covington.

	<i>Fet.</i>	<i>Inches.</i>
1. Soil and yellow drift clay.....	3	4
2. Drab argillaceous shale.....	8	6
3. Dark bituminous shale.....	2	0
4. Coal	1	0
5. Fire-clay	1	6
6. Light gray siliceous shale.....	8+	0

Of these, Nos. 2 and 5 are good commercial clays and can be made into many kinds of products. No. 6 is too siliceous to be used alone, but united with the others will increase their value for brick-making purposes.

Farther south, on land formerly owned by Monroe Carwile, potters' clay of good quality is found in an outcrop beneath coal I, exposed to a thickness of three feet. A partial analysis of this clay by Kramer, showed its chemical constituents could be classed as follows:

	<i>Per Cent.</i>
Clay base and sand.....	91.02
Fluxes	4.90
Moisture and volatile.....	4.08

Its composition seems suitable for stoneware and hollow brick.

Two and a half miles south of Covington, at an abandoned coal mine on the land of Peter Anderson, south half of the southwest quarter of section 12 (19 north, 9 west), a deposit of blue-gray argillaceous shale five feet in thickness overlies 30 inches of coal, beneath which is a vein of fire-clay the thickness of which has never been determined. Both shale and fire-clay are of good quality, and mined in connection with the coal, will well repay the working.

Township 18 North, Ranges 7, 8 and Part of 9 West.

On a small tributary of Coal Creek, in section 3 (18 north, 8 west), is an exposure of gray argillaceous shale 35 feet in thickness. Beneath this is a seam of coal 3 feet 8 inches thick, and below the coal a stratum of fire-clay of unknown depth. Both shale and clay are well suited for manufacturing purposes. Southwest of this, close to the Parke County line, in section 36 (18 north, 9 west), occurs a deposit of the better grade of potters' clay.

In the southeast quarter of section 18 (18 north, 8 west), a blue shale comes near to the surface over a large area of land owned by J. C. Graham. It is six feet thick at the outcrops and, according to Kramer, its chemical constituents represent:

	<i>Per Cent.</i>
Clay base and sand.....	84.14
Fluxes	12.17

Beneath this shale are two thin seams of coal, separated by a stratum of a fair quality of fire-clay three feet in thickness.

On the land of John R. Teegarden, northeast quarter of section 9 (18 north, 8 west), about one-half mile northwest of the Clover Leaf Railway, coal V is being stripped for local use. According to the owner, "Seven feet of dirt and three feet of blue limestone? are being removed to get at the coal, which is semi-block, five feet thick, and of good quality."

Beneath the coal is nine feet of a dark, bluish-gray under-clay, which weathers into a fine grained very plastic material, free from grit and other impurities. An analysis of this clay made by Dr. W. A. Noyes for this report showed its chemical constituents to be as follows:

Analysis of Under-Clay from Land of Jno. R. Teegarden, Near Kingman, Ind.

Silica (SiO_2)	71.91
Titanium oxide (TiO_2) .....	.31
Alumina (Al_2O_3)	17.62
Water combined	5.37
<hr/>	
Clay base and sand	95.21
Ferric oxide (Fe_2O_3)	2.55
Ferrous oxide (FeO}) .....	.40
Lime (CaO}) .....	.43
Magnesia (MgO}) .....	.17
Potash (K_2O)	2.00
Soda (Na_2O}) .....	.15
<hr/>	
Fluxes	5.70
<hr/>	
Total	100.91

The analysis shows the material to be—what its appearance indicates—a high grade under-clay suitable for stoneware, hollow brick, sewer pipe, fireproofing and many forms of ware now made at other points in Indiana. By comparing the composition of the Teegarden clay with that of the famous stoneware clays of Akron, Ohio (see p. 78), it will be noted that the two are very similar; the refractory and fluxing ingredients, when compared, showing:

	<i>Teegarden Clay. Per Cent.</i>	<i>Akron, Ohio Clay. Per Cent.</i>
Clay base and sand	95.21	94.65
Fluxes	5.70	4.54

Used in connection with the overlying coal, which could be readily mined by either slope or shaft, this deposit offers an excellent site for a stoneware or other clay factory.

On Sugar Mill Creek, section 25 (18 north, 7 west), at the lower end of the "Narrows," a blue-black argillaceous shale outcrops in places along the bluff, and a well section one-fourth mile east of the creek shows the shale to be 35 feet thick.

At the Coates or Byrd mine in the southeast quarter of section 33 (18 north, 7 west), 18 feet of gray to blue shale of good quality overlies coal V, which is here in two layers, each two feet or more in thickness, and separated by a bone coal six to eight inches thick. The fire-clay below the coal is but two feet thick and merges into sandstone.

At Yeddo, on the C. & E. I. Railway, six feet of a good quality of fire-clay underlies the worked vein of coal, which is four feet ten inches in thickness.

On the Aaron Lindley farm, southwest of southeast of section 17 (18 north, 8 west), three quarters of a mile west of Cates, a station on the Clover Leaf Railway, coal Va is only eight or nine feet below the surface. A section shows:

Section on Lindley Farm, near Cates.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil and yellow clay.....	2	0
2. Drab shale	3	0
3. Gray limestone, fossiliferous.....	0	6
4. Drab shale	3	0
5. Coal Va	2	6

The shales Nos. 2 and 4 are of good quality for either ordinary or vitrified brick.

One-half mile northwest of Snoddy's Mills, northwest quarter of section 1 (18 north, 9 west), coal V is being worked by Cook & Herming. At their drift or slope shaft the following section was secured:

Section Northwest of Snoddy's Mills.

	<i>Feet.</i>	<i>Inches.</i>
1. Clay shale	0	3
2. Coal Va	1	0
3. Soft clay shale	12	6
4. Black sheety shale	1	6
5. Gray calcareous shale	0	3
6. Coal V	3	7
7. Fire-clay	2+	0

Nos. 3 and 7 of the section are suitable for vitrified and kindred clay wares.

At Silver Island, on a switch of the Clover Leaf Railway, section 34 (18 north, 9 west), the following section is exposed near the sulphur spring:

Section at Silver Island.

	<i>Feet.</i>	<i>Inches.</i>
1. Black sheety shale.....	1	0
2. Coal VIa	1	4
3. Brown sandstone	0	10
4. Fire-clay running into light gray shale, not well exposed	12	0
5. Concealed	5	0
6. Dark blue shale.....	3	0
7. Black sheety shale with septaria.....	2	8
8. Coal VI	1	6
9. Gray fire-clay	4	0
10. Coal	1	0
11. Fire-clay	6	0
12. Drab shale	4	0
13. Sandy ironstone	1	0

Of the strata here shown, Nos. 4, 5, 6, 9, 11 and 12, aggregating 34 feet in thickness, are suitable for vitrified wares and ordinary and pressed front brick. With railway facilities present and cheap fuel in abundance, this furnishes a good site for a large clay factory.

At the Silver Island mine, a short distance away, coal V, four feet, six inches in thickness, is mined from a depth of 45 feet. The coal is overlain with black sheety shale, but underlain with 20 feet of under-clay suitable for many different vitrified products.

Surface drift clays are used at three or four yards in Fountain County for making ordinary brick and drain tile.* At Covington, W. H. Prather uses 42 inches of clay after stripping the grass roots, to make common brick, and drain tile four to ten inches in size.

At Steam Corner a dark loam 15 inches thick is stripped and the under-lying clay used to a depth of three and a half feet in making drain tile. At Kingman eight inches of soil are removed and 36 inches of surface clay used; while at Veeders-

*See statistical table near end of paper.

burg, after stripping six inches of loose black soil a "strong, tough tile clay" is utilized for drain tile.

The above comprise all the clay deposits of note in Fountain County which have come under the notice of the writer. A careful and detailed survey of each congressional township in the county would doubtless bring a number of others to light. Many of those described are situated by the side of or within easy reaching distance of the four railways which pass through the county. All such would soon repay the investment of capital necessary for their development, provided practical and experienced clay workers were put in charge of the plants which were erected.

WARREN COUNTY.

This county is a little north of the center of the western border of the State. It lies south of Benton County and east of the Illinois line. Tippecanoe County lies east of the northeastern corner of the county, while Fountain County is east and south of Warren, from which it is separated by the Wabash River. Vermillion County lies south of the southwestern corner. The county is somewhat triangular in shape, with the northeastern and southwestern corners of the triangle truncated. It has an area of 366 square miles.

The Geological Epochs represented in the surface rocks are the Knobstone of the Lower Carboniferous and the Mansfield Sandstones and Coal Measures of the Carboniferous Periods. The Knobstone occurs beneath the drift in the northeastern corner and is exposed in a narrow strip along the north side of the Wabash from the point where that stream enters the county to a short distance below Williamsport. The Mansfield Sandstone covers a larger portion of the eastern half of the county, and also outcrops along the Wabash from near Williamsport to within four miles of the southern border. The Coal Measure rocks lie just beneath the heavy drift of the remainder or western half of the county.

The western and northern part of the county is a high, rolling prairie, deeply covered with glacial drift, much the same as in Benton County, just to the north. Approaching the Wabash River, this level country is much broken up by the larger streams

and their tributaries which, as they near the Wabash, often acquire steep or precipitous banks, often walled in by perpendicular bluffs of sandstone. These bluffs, as well as those along the Wabash, are often 80 to 150 feet high. Along the river is a flat terrace, some 80 feet above low water mark. It is a terrace of planation, the rock at many points coming very near the surface. At other points it is cut out of glacial material, which still extends as much as 60 feet or more below its level. This terrace varies from half a mile to a mile in width. Away from the Wabash River or the channel of Pine Creek, the glacial drift is quite deep, ranging up to 250 feet in thickness. Approaching the river, or its larger tributaries, the more rapid erosion has greatly reduced that thickness, so that along some of the streams the underlying strata are quite frequently exposed. Over the county as a whole the drift will probably average less than 100 feet in thickness.

As already noted, the Wabash River flows along the southeastern side of the county. Its principal tributaries from the north and west are Little Pine, Kickapoo, Pine, Rock and Redwood creeks, Possum Run and the north fork of Spring Creek, which flows south through a corner of Vermillion County. Mud Pine and Fall creeks are the principal tributaries of Pine Creek from the west. Jordan Creek rises in the northwestern portion of the county and flows southwestward into Illinois.

Transportation facilities are, in the south and eastern portions of the county, good; while in the northwestern third they are wholly lacking. The Chicago & Eastern Illinois crosses the county from north to south in the northeastern part. The Wabash enters the county above Williamsport and runs west and southwest, leaving at the State Line. A branch of the Illinois Central Railway enters the county from the west and meets the Wabash at West Lebanon. The Peoria Division of the Big Four crosses the southern edge of the county from east to west.

The remains of a thin seam of coal VIa occur in a number of places in the southern part of the county, but this uppermost vein has, for the most part, been cut out by preglacial erosion. Between it and coal VI is a space three to 30 feet in thickness which, in most places, is filled with an under-clay and drab to gray clay shale, both of good workable quality.

The under-clay beneath coal VI is of fair quality and ranges up to four and a half feet in thickness. Between this under-clay and coal V, the space is mostly filled with limestone and black sheety shale, no workable clays being found. Beneath V there is little or no clay material of value, unless it be the under-clay of coal I, which, in a few places, where weathered, is suitable for terra cotta and stoneware. The Knobstone shales found along the Wabash in the northeastern part of the county are, for the most part, too sandy for use, though local pockets doubtless occur which will make ordinary, dry pressed or vitrified brick.

Township 23 North, Ranges 7, 8, 9 and Parts of 6 and 10 West.

This area of 138 square miles lies along the northern border of the county, and is almost wholly covered with heavy drift, so that few exposures of clay are visible. The only one worth noting occurs at the site of the old McKey coal banks, on Mud Pine Creek, northeast quarter of section 29 (23 N., 8 W.). Here coal VI¹, three feet two inches thick overlies three feet of drab under-clay of fair quality for terra cotta and hollow vitrified products.

Township 22 North, Ranges 8 and 9 and Parts of 6, 7 and 10 West.

This area of about 120 square miles forms the second tier of townships from the north border. Its western portion is heavily drift covered; but near the center, in 22 N., 8 W., are some fair exposures of coal and clays.

At Kickapoo Falls, in the northwest quarter of section 29 (22 N., 7 W.), about 20 feet of black to drab clayey Knobstone shales are exposed beneath 60 feet of massive Mansfield Sandstone. In the northeast corner, section 14 (22 N., 7 W.), a well on the J. L. May place passed through 44 feet of rather soft shale, below 60 feet of drift.

The most promising beds of under-clay in the county are probably those exposed beneath coal VIa in slope mines along Fall Creek, in sections 20 and 21 (22 N., 8 W.). Just above the Thomas slope in the northeast of section 20 the following strata are exposed:

Section Near Thomas Slope, on Fall Creek.

	<i>Feet.</i>	<i>Inches.</i>	<i>Feet.</i>	<i>Inches.</i>
1. Drift	2	0	2	0
2. Sandstone	3	6	5	6
3. Soft bluish shale.....	0	7	6	1
4. Coal VIa	0	10	6	11
5. Gray sandy under-clay.....	5	11	12	10
6. Coal VI	0	10	13	8
7. Soft light drab under-clay.....	2	0	15	8

The upper under-clay, No. 5, is rather hard when first exposed, but soon weathers into a soft, plastic material, suitable in high degree for all kinds of hollow vitrified wares, such as conduits, fireproofing, hollow block, flue linings, etc. The lower clay, No. 7, is softer, less siliceous and more inclined to be waxy than No. 5. It could be mixed with the latter for many purposes.

A little farther down Fall Creek from the Thomas slope, the upper coal VIa is lacking, but just below its proper place is 11 feet of under-clay corresponding to No. 5 of the above section, while coal VI beneath is underlain with five feet of the same character as No. 7, above given.

At the Carlsen bank, in the northwest quarter of 21, coals VIa and VI are separated by 11 feet of a good quality of under-clay, the lower portion of the stratum merging into gray clayey shale. The entire body of clay could be utilized and, by taking it out, both veins of coal, the upper, one foot ten inches, and the lower about three feet in thickness, could be mined. The most discouraging feature of these excellent clay deposits is their distance from transportation; the nearest railway, the Wabash, being about four miles to the south.

At the Hogue mine, in the southeast quarter of section 16 (22 N., 8 W.), coal V, 50 feet from the surface, is underlain with a thin stratum of under-clay, while just below the latter is eight to 12 feet of drab to gray clay shale.

Township 21 North, Range 9 and Parts of 8 and 10 West.

This area of about 72 square miles lies near the center of the county, and contains the two largest towns, viz., Williamsport and West Lebanon. But few, if any, deposits of workable clays, other than surface drift clays, occur in the area. In the south-

east of the southwest of section 11, about a mile south of Williamsport, is an outcrop of coal V? overlying the Mansfield Sandstone, here 35 to 40 feet thick, from which it is separated by from two to four feet of under-clay. It is overlain by a foot or so of sandy shale, and that in turn by sandstone.

At West Lebanon a shaft and bore for coal in the southwest quarter of section 12 (21 N., 9 W.), disclosed coal VIa, one foot, six inches thick, at a depth of 111 feet. Beneath the coal, and separating it from coal VI, was a stratum of under-clay and clay shale seven feet in thickness. Coal VI was less than three feet thick and overlaid five feet of under-clay. On account of the thinness of the coals the shaft was abandoned and the clays are not available, though they are doubtless of good workable quality.

The only clay working establishment at present in Warren County is the drain tile mill of Alexander Hamar at West Lebanon. The tile are made of drift clay, about three feet of which is used, after stripping four to six inches of soil. All sizes up to 12 inches are burned, the value of the output in 1904 being about \$5,000.

Township 20 North, Parts of Ranges 9 and 10 West.

In this area of about 33 square miles in the southern part are the principal coal outcrops and mines of Warren County. The Peoria Division of the Big Four Railway crosses the southern part of the area. The C. & E. I. formerly had a branch to Coal Creek (Stringtown), Fountain County, which crossed township 20 north, 9 west, diagonally. The Wabash River crosses the northwestern corner.

The principal exposures of coal and accompanying clays are in the northeastern part of 20 north, 9 west. At the old Hooper & Barringer shaft on Opossum Run Creek, in the northeast quarter of section 8, the following section was exposed to below the under-clay of coal VI:

Section of Old Hooper & Barringer Shaft.

	<i>Feet.</i>	<i>Inches.</i>	<i>Feet.</i>	<i>Inches.</i>
1. Soil	3	0	3	0
2. Yellow clay with float coal.....	9	0	12	0
3. Clay shale changing to shaly sandstone	12	6	24	6

4. Clay shale with ferns.....	0	6	25	0
5. Coal VI	2	8	27	8
6. Under-clay	3	6	31	2

The under-clay No. 6 is buff or gray, very plastic, and after weathering, will prove suitable for stoneware, terra cotta, vitrified tile and all kinds of hollow vitrified products. The old spur of the C. & E. I. Railway running past this shaft is now abandoned.

In this region the space between coals VIa and VI varies from three feet six inches to above 20 feet as far as observed. It often contains only fire-clay and shale of good quality, but where the space approaches its maximum the shale tends to be sandy or to turn into sandstone.

Along Coal Run, in sections 9 and 10 (20 N., 9 W.), a bed of hard, sandy, light gray under-clay of fair quality, two to four feet thick, generally underlies coal VI. The clay here is in most places about drainage level, sometimes a few feet below drainage. The following is an average section:

Section at Dicky Drift, No. 2, Southwest of Section 10.

	<i>Feet.</i>	<i>Inches.</i>
1. Drift.		
2. Shelly sandstone	6	0
3. Coal VI	0	7
4. Sandy under-clay	0	2
5. Coal VI	1	2
6. Sandy under-clay	0	7
7. Coal VI	0	4
8. Under-clay	3+	0

In the southwest of section 10, on the Jones place, the under-clay beneath coal VI is four or more feet thick, while in the northwest quarter of section 2, coal VIa overlies three or more feet of white plastic under-clay with little grit.

At the shafts on the Rodgers place, opposite Covington, on the west side of the Wabash River, southeast quarter of 27 (20 N., 9 W.), the worked coal IV? has over it in places about one foot of good fire-clay, but this runs so frequently into shelly sandstone and shale that it is not workable. The under-clay beneath the coal is here only 14 to 16 inches thick, with many fern impressions.

PARKE COUNTY.

Parke County is situated in the western part of the State, due west of Indianapolis. It lies south of Fountain and part of Montgomery; east of Vermillion; west of Putnam and Montgomery, and north of Clay and Vigo counties. It is nearly rectangular in shape, having a length of 24 miles from north to south, and a width of about 20 miles, from east to west, its area being 453 square miles.

The surface rocks of the county represent five Geological Epochs, viz., the Knobstone and the Harrodsburg and Mitchell limestones of the Lower Carboniferous, and the Mansfield sandstone and Coal Measures of the Carboniferous Periods. The Knobstone outcrops only along Sugar Creek in the extreme northeastern corner of the county; while the two Lower Carboniferous limestones come to the surface over small areas along the streams in its eastern third. The entire area covered by the exposures of these three formations is less than ten square miles. The Mansfield sandstone covers an area of about 115 square miles, embracing a strip one to eight miles wide for nearly the full length of the eastern third of the county. The remainder of the county, comprising nearly 75 per cent. of its area, is underlain by rocks of the Coal Measures.

Parke is one of the best drained counties in Indiana. The Wabash River, flowing along its western border, receives the waters of Coal Creek, Sugar Creek and Raccoon Creek. The latter two streams rise east of the county, flow entirely across it, and carry an abundance of water. All along the eastern side of the Wabash the bottom lands tend to have a width of one or two miles, back of which rise the bluffs from 100 to 250 feet high. Sugar Creek appears to be flowing through a post-glacial channel, as far as the mouth of Rush Creek, its immediate valley being usually narrow and often hemmed in by cliffs of sandstone, yielding many excellent exposures of the Coal Measure rocks, and affording, in the vicinity of "Turkey Run," some of the most picturesque scenery of the State. Its principal tributaries from the north are Rush Creek and Sugar Mill Creek; while from the south enters Roaring Creek which, in the lower part of its course, winds through a narrow rocky ravine. Many of the smaller tributaries of Sugar Creek are, over the lower part of their

courses, enclosed in rocky gorges, with perpendicular or overhanging walls, these gorges being often from 50 to 100 feet deep and sometimes of a less width at the top than their depths, as at Turkey Run.

Raccoon Creek and its principal tributary, Little Raccoon Creek, occupy their preglacial channels as far as Rosedale, above which point they have broad bottoms and yield but few exposures. The principal tributaries of the main stream are Leatherwood, Rocky Run, Iron Creek, Stronger's Branch, Rocky Fork, Troutman's Branch, and Little Raccoon with its tributaries, Wiesner's Branch, Williams' Creek and Sand Creek.

Due to the abundance of its streams, the surface of Parke County is much broken, especially in the eastern part, where the divides tend to become sharp-crested ridges. There are, however, all over the county, small, scattered patches of level land so characteristic of a glaciated region. The county lies entirely within the drift covered area, though as a rule it is not so deeply buried as the counties to the north. The drift may be said to range between 25 and 75 feet, averaging nearer the former, and occasionally running over the latter up to probably 150 feet. A terminal moraine crosses the county from east to west across the southern end, producing hummocky topography and unusual depth of drift wherever the erosion has left it undisturbed.

The county is fairly well supplied with railway facilities. One division of the C. & E. I. Railway runs north and south through the western third, while another cuts across the southwestern corner. The Springfield Division of the C., H. & D., formerly known as the I., D. & W., crosses from east to west, north of the center; the T. H. & L. Division of the Vandalia crosses from northeast to southwest; while the Central Indiana Railway, leaving the latter at Sand Creek Station, runs east of south to Brazil, Clay County.

The most valuable clay deposits of Parke County are found west of the Mansfield sandstone area in the northwestern, western and southern townships. The numerous streams of the county have, in many places, eroded deep beds through the surface strata, exposing the latter to view and affording excellent opportunities for discovering the thickness and character of the Coal Measure rocks, to which the majority of the clays belong.

Township 17 North, Ranges 6, 7 and 8 West.

In the northern tier of townships in the county transportation facilities are poor, and but few reported clay deposits were visited. On a small tributary of Sugar Creek from the south in section 8 (17 north, 6 west), is an outcrop of blue shale resembling that so extensively used at Veedersburg, Indiana, for making vitrified brick. This deposit varies from 20 to 40 feet in thickness along the bluff.

On the H. Litsey farm, southwest quarter of section 26 (17 north, 7 west), the following section is exposed on Gateswood Branch:

Section on Litsey Farm, Sugar Creek Township.

	<i>Feet.</i>	<i>Inches.</i>
1. Coal, bony, usually replaced by shale.....	1	6
2. Fire-clay	2	0
3. Hidden	2	0
4. Shaly to massive sandstone.....	3 to 8	0
5. Blue to gray shale.....	14	0
6. Hidden	6	0
7. Blue shale	6	0
8. Black shale, bottom bituminous and locally replaced by No. 9.....	2	0
9. Coal	0 to 1	0
10. Gray to brown fire-clay.....	1	6
11. Gray shaly sandstone.....	3	0
12. Gray sandy shale running into blue shale....	20	0

Of the strata exposed, Nos. 2, 3, 5, 7, 10 and 12, aggregating nearly 50 feet in vertical thickness, consist, for the most part, of good working, clayey material. A short distance south of this coal has been extensively mined for local use. The nearest railway is the C., H. & D., three miles south. For nearly two miles above the "Narrows" high shale bluffs are numerous, the exposures reaching a thickness of 75 or 80 feet. It is, for the most part, a black fissile, argillaceous shale, containing more or less iron pyrites and clay ironstones and interstratified with thin seams of coal and fire-clay. In places along this bluff there is considerable sandstone in the shale, in other places there is very little.

Heavy beds of shale are also found along Sugar Mill Creek, in sections 4, 10, 21, 28 and 29 (17 north, 7 west). The largest of these, and the one in the best position for working, is at the

"Pinnacle" on the west side of the creek, southeast quarter of section 21 (17 north, 7 west). At this point the creek cuts off the end of a narrow ridge 50 feet high, having a narrow ledge of sandstone 10 feet thick on top; the lower 40 feet consisting of drab to black colored shale. The shale lies in a heavy bed in the northern part of section 28, on the south side of the creek, where it contains a bed of coal nearly three feet thick.

On the southeast quarter of section 24 (17 north, 8 west), two and a half miles east of the C. & E. I. Railway, the following section is exposed at the Russell mine:

Section at Russell Mine.

	<i>Feet.</i>	<i>Inches.</i>
1. Hill, covered	50	0+
2. Gray shale	6	0
3. Sandstone and shale	8	0
4. Dark drab shale.....	18	0
5. Coal (from bed below).....	0	10
6. Yellow sandstone	4	..
7. Coal IV	4	0
8. Under-clay	2	6

The shales, Nos. 2 and 4 of the section, and the under-clay, No. 8, can all be made into vitrified wares; while the accompanying coal will furnish fuel sufficient for their burning.

In the northeast quarter of section 29 (17 north, 8 west), 25 feet of gray shale is exposed by the roadside where the road descends the bluff. South of this, on the Bowser place (section 32), several thick strata of shale and under-clay outcrop, but the stripping above them is extensive.

Township 16 North, Ranges 6, 7 and 8 West.

The second tier of townships in the county contain some excellent clay deposits. Along Sand Creek, north and west of Nyesville, in sections 27, 33 and 34 (16 north, 7 west), Coal V has been extensively mined, a switch from the T. H. & L. Railway having been constructed to the mines. In this vicinity coal IV lies 18 to 30 feet below coal V, and the interval is mostly taken up with the under-clay of V, and a deposit of blue to gray shale of good quality. A six-foot vein of excellent under-clay also underlies IV. Railway facilities, fuel

and raw material being all present, the location is a good one for a large clay industry. The clay will, however, have to be mined, as the stripping is heavy throughout the region.

In the vicinity of Bloomingdale and Annapolis, in township 16 north, 8 west, occur some deposits of potters' clay which have been extensively used in local potteries. Since the year 1840 a clay for the making of stoneware has been obtained from a point one mile southwest of Bloomingdale, in the northwest quarter of section 23 (16 north, 8 west). A branch of Leatherwood Creek flows through this area, and at several points along its low bluffs the clay is obtained by stripping. At the time of my visit the following section was obtained at the latest worked pit:

Section Southwest of Bloomingdale.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil and drift. clay.....	3	0
2. Gravel	3	4
3. Coarse siliceous fire-clay.....	3	3
4. "Iron sandstone"	1	10
5. Fine grained potters' clay.....	8	0

The potters' clay (No. 5) is of a grayish or lead color, quite soft and plastic, and much more so when washed and kneaded. It contains a large amount of free silica in very fine grains and, at scattered intervals, scales of white mica are discernible. It burns to buff or cream color, and takes a handsome dark glaze with Albany slip clay.

A partial analysis by Dr. J. N. Hurty showed the following percentage composition:

Analysis of Potters' Clay from Near Bloomingdale.

Silica (SiO ₂)	69.41
Alumina (Al ₂ O ₃)	18.81
Clay base and sand.....	88.22
Magnesia (MgO) .....	.54
Lime (CaO) .....	.90
Ferric oxide (Fe ₂ O ₃).....	2.64
Fluxes	4.08
Water and volatile matter.....	7.65

While the amount of potash and soda were not determined by Dr. Hurty, the percentage of fluxes present is not so great but

that it will stand up under heat sufficient to melt the slip clay used for glazing—a fact which experience has fully verified.

This stratum of potters' clay covers a large area south and west of Bloomingdale. Its maximum thickness is not known, but it has been reported that at a point one-quarter of a mile east of where the above section was obtained, 30 feet of it was passed through in digging a well. No charge has ever been made for it by the owners of the land, but for more than fifty years it has been washed by potters near the place where mined, and then hauled in wagons six miles to Rockville. It has also been used extensively in a pottery at Bloomingdale, and to a small extent in one at Annapolis. Many pits have been opened along the bluffs of Leatherwood, worked back a short distance, and abandoned as soon as the stripping became in any ways heavy. In almost all of these the clay was very uniform in character and quality, though in a few the presence of small nodules of iron carbonate detracted somewhat from its value.

The coarse, siliceous clay (No. 3 of the above section) has been used at Bloomingdale in making a cream colored drain tile. Mixed with surface clay it also burns into a good quality of building brick. In some places, however, it contains too many pebbles of limestone from the overlying gravel to be of any value. The "iron sandstone" (No. 4) separating the two clays, is a very heavy and hard, dark colored, coarse grained rock, evidently a combination of some ore of iron and sand.

In the northeast quarter of section 22 (16 north, 8 west), one-half mile west of the pit where the above section was taken, a stratum of clay outcrops a few feet above the bed of Leatherwood Creek. Although possessing at this place the physical appearance of a gray siliceous shale, its behavior under heat proves that it is an under-clay, as it has undoubted refractory properties and burns to a handsome buff color. Its composition, as far as determined by Kramer, is as follows:

Analysis of Under-Clay on Leatherwood Creek.

	<i>Per Cent.</i>
Silica (SiO_2) (total).....	73.32
Alumina (Al_2O_3)	16.06
Magnesia (MgO}) .....	.70
Lime (CaO}) .....	.70
Ferric oxide (FeO).....	1.10
Moisture and volatile.....	8.12

This under-clay is hard when first mined, but soon weathers into a soft, plastic mass. The thickness of the stratum has not been determined. Its known properties are such as to merit further investigation.

A bore put down on the Myers farm, just north of the C., H. & D. Railway, in the west half of the northwest quarter of section 22 (16 north, 8 west), encountered the following strata:

Section of Bore on Myers Farm.

	<i>Feet.</i>	<i>Inches.</i>
1. Reddish clay	8	0
2. Dark sandy shale.....	7	0
3. Black gumbo; possibly place of coal.....	3	0
4. Fine fire and potters' clay.....	6	0
5. Potters' clay and shales in layers.....	64	0
6. Coal	0	5
7. Fire-clay, potters' clay and shales of various colors	32	0
8. Coal	2	0
9. Fire-clay, potters' clay and shales.....	86	0

This bore indicates the presence of an abundant supply of clay working material which can be secured by mining; but it proves a lack of fuel for its burning. However, the latter can be gotten in abundance at Mecca and other points a few miles to the south-west.

Three miles northwest of Bloomingdale, on the land of R. A. Coffin, northeast quarter of section 9 (16 north, 8 west), is the head of "Coke Oven Hollow," a deep ravine leading down to Sugar Creek, and long locally noted for the quantity and variety of its clays. A pottery was established in this ravine in 1866, and continued in operation until 1891. It was located on ground made vacant by the mining of under and potters' clay for shipment over the old Wabash & Erie Canal, which was connected by a feeder with the mouth of the ravine, and for use in the pottery at Annapolis.

A connected section of the strata, in the upper half of this ravine is as follows:

Section in Coke Oven Hollow.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil and yellow drift clay.....	8	0
2. Buff clayey shale.....	27	0
3. Hard gray sandy shale.....	4	6

4. Coal V	1	3
5. Under-clay	3	4
6. Blue clayey shale.....	8	8
7. "Iron sandstone"	1	6
8. Plastic potters' clay.....	22	0
9. Dark, hard, sandy shale, merging into sand rock.	21	0
10. Coal IV	2	8
11. Under-clay	3	10

The potters' clay (No. 8) is doubtless the same stratum as the one worked south of Bloomington; the overlying "iron sandstone" of the two being identical in appearance. In its crude form the potters' clay at "Coke Oven Hollow" contains more or less impurities, but when carefully washed and mixed with about one-eighth its bulk of under-clay, it burns into that strong, gray, vitrified stoneware which, since 1841, has been made at the Annapolis pottery.

The two shales (Nos. 2 and 6 of the above section) are valuable deposits; suitable in the highest degree for paving brick, sewer pipe or other vitrified products. The fire-clays (Nos. 5 and 11) are also excellent in quality. Sample brick, made from the lower clay (No. 11) have been tested a number of times and have held their own in refractory properties with the best fire brick in the market. Large quantities of this clay were formerly shipped by the canal to Toledo, Ohio, and points in northern Indiana. The sandy shale (No. 9) contains too large a percentage of silica and mica, in coarse particles, to be of value.

The outcrops of the lower vein of coal (No. 10) have been mined for many years. It is a bituminous coal of good quality, and, locally, much valued for smithing purposes. Taken by itself the vein is too thin for profitable working. Mined in connection with the overlying clays as fuel for their burning, a profitable industry could be started here were it not for the lack of transportation facilities. Until these are secured the valuable mineral deposits of "Coke Oven Hollow" must remain practically undeveloped.

In the vicinity of Montezuma, Parke County, and Hillsdale, Vermillion County, are found some of the largest and best deposits of shale and under-clay occurring in the State of Indiana. The Wabash River, flowing almost due south between the towns mentioned, forms the boundary line separating the two counties.

Montezuma is situated on the eastern bank of the river, on the edge of a river terrace, 35 feet above low water mark. This level terrace or river plain extends eastward one and one-half miles and there meets the bluff or upland which marks the eastern bank of the old river channel. On the western side of the river a stretch of level land, overflowed during high waters, extends for three-fourths of a mile to a very narrow terrace, on which the town of Hillsdale is partly located, and from the western side of which the bluffs, marking the western bank of the old river, rise abruptly.

The deposits of shale and fire-clay above mentioned are found in the bluffs on both sides of the Wabash River. The C., H. & D. Railway runs east and west through Montezuma and Hillsdale. One-eighth of a mile west of where it strikes the bluff in Parke County it is crossed by the C. & E. I. Railway running north and south. A tract of 120 acres of land, located in the southeastern angle of their intersection, is owned by the Marion Brick Company which, since 1895, has operated here the largest ordinary brick plant in the State. A short distance east of their factory is the Montezuma plant of the National Drain Tile Company, which secures raw clay from the land of the Marion Brick Company.*

A connected section obtained on the sides of the bluff and in a well at its base on this land, and on that of Thomas Morgan, southwest quarter section 31 (16 north, 8 west), adjoining it on the south, disclosed the following strata:

Section Near Plant of Marion Brick Co., East Montezuma.

	<i>Feet.</i>	<i>Inches.</i>
1. Surface soil and gravel.....	8	0
2. Drab argillaceous shale.....	12	0
3. Clay ironstone	0	3
4. Black bituminous sheety shale.....	1	4
5. Drab sheety shale.....	1	0
6. Coal Va	1	2
7. Under-clay	7	0
8. Gray to brownish sandy shale.....	14	0
9. Gray to blue clayey shale.....	29	0
10. Dark bituminous shale.....	1	4
11. Coal Va	1	8
12. Under-clay	1	0
13. Blue shale	9	0

*Full details regarding these two plants will be found under a later section entitled "The Clay Industries of Indiana."

The pit of the Marion Brick Company has been opened to a depth of 56 feet for 200 yards or more along the slope of the hill, so that only the strata Nos. 8 to 12 are exposed. From the section it will be seen that not less than 58 vertical feet of workable material are comprised in the shales Nos. 2, 9 and 13, and the two under-clays, Nos. 7 and 12, at the points mentioned. The gray sandy shale, No. 8 of this section, merges into a shaly sandstone, too siliceous for use, at a number of points in the pit, and hence necessitates heavy stripping to get at the main bed of shale, No. 9.

This bed of bluish-gray shale is so soft as to be easily scratched by the nail, exceedingly fine grained, and has a very smooth and unctuous feel. Where exposed vertically by erosion, it weathers at first into small quadrangular blocks a few inches in surface dimensions. These in time break up into finer particles, which are washed down and give a characteristic grayish yellow tinge to the surface of the bluff for miles in either direction. Occasional nodules of kidney iron ore are found in the lower part of this stratum.

When burned to near the point of vitrification this shale becomes a bright cherry red. When vitrified it is a dark brown, but if heated beyond this point it quickly becomes black, porous and worthless. It is especially suited for making vitrified products, such as sewer pipe and hollow brick and also dry pressed brick for the fronts of buildings. It also makes an excellent roofing tile, as the very thin sheets of clay, when properly prepared for the kiln, do not shrink or warp to any appreciable extent while burning. For ten years it has been used for ordinary brick by the Marion Brick Company. In June, 1904, this company was using a steam shovel which excavated 660 cubic yards per day, all of which was used at their plant, being hauled up an incline in cars holding three cubic yards each.

The upper under-clay, No. 7, where exposed on the Morgan land, is an almost white, highly siliceous deposit, remarkably free from oxides of iron and other impurities. Large quantities of it were formerly burned into fire-brick and saggars by a roofing tile company at Montezuma. The brick were finer in texture and more compact than those made from the fire-clay at Hills-

dale and Highland, across the river. For the purposes used, their refractoriness gave the highest satisfaction.

The National Drain Tile Company have one of their four Indiana factories located about 600 feet east of that of the Marion Brick Company, and use clay from the same general deposit, paying therefor a royalty of 5 cents per ton. In the words of the president of that company, "they had better have paid \$1,000 an acre for the land than royalty of 5 cents per ton for five years."

In June, 1904, the tile company was securing clay from a low spur of the main hill, a section at their pit showing:

Section of Pit of National Drain Tile Co., East Montezuma.

	<i>Feet.</i>	<i>Inches.</i>
1. Yellow surface clay.....	6	0
2. Drab to blue shale.....	5	0
3. Dark bituminous shale.....	1	6
4. Coal Va	1	8

All of Nos. 1 and 2 are intimately mixed and worked into drain tile four to 30 inches in size. These tile are not vitrified, being burned only three to four days. Some care has to be taken with the larger sizes as they are liable to crack while drying. Otherwise the mixture of raw material seems in every way suitable for a durable product of a handsome, dark cherry red color. The water supply of both these large plants is pumped from Leatherwood Creek to a height of 150 feet into storage tanks on top of the hill just south of the factories.

The bluff for two miles north and nearly the same distance south of the plant of the Marion Brick Company is largely composed of the above mentioned shales and fire-clays. On the lands of O. P. Brown, sections 30 and 19 (16 north, 8 west), one-half mile east of the C. & E. I. Railway, the shales are especially notable; at one point, the northwest quarter of section 30, the exposure of the gray and blue varieties together measuring 51 feet in vertical thickness.

By the side of the Rockville and Montezuma road, on the land of Benjamin Phillips, valuable deposits of similar materials also occur. A bed of buff shale 25 feet thick overlies a thin seam of coal. Beneath this is a vein of fire-clay six feet in thick-

ness, and lower down a deposit 12 feet thick, of superior argillaceous shale of the kind locally known as "soapstone." Both this and the upper shale are very free from impurities and weather into a very fine-grained, plastic clay. The point where they are found is one and a half miles from the C., H. & D., and one mile from the C. & E. I. Railway.

Township 15 North, Ranges 6, 7, 8 and 9 West.

West of Hollandsburg, in section 9 (15 north, 6 west), is a conspicuous bluff along a small tributary of Raccoon Creek, in which 26 feet of yellow and drab argillaceous shale is exposed, and can be easily secured by stripping. On the hill north of Ferndale, section 27 (15 north, 6 west), is a bed of drab argillaceous shale more than 30 feet thick, overlain by a heavy bed of drift. Both of the above deposits will be found suitable for vitrified products.

On the east side of Troutman's Branch, west of the Hollandsburg-Mansfield road, near the middle of section 16 (15 north, 6 west), is a nearly perpendicular bluff of blue-drab shale 40 feet or more in thickness, with little covering. The upper part of the bed has a dull yellow to buff color, the lower part a blue-drab. The shale is nearly uniform in texture throughout the bed, except a stretch three to four inches thick near the middle, which is a fine grained sandstone.

A section of the bluff shows:

1. Glacial drift and soil.....2 to 3 feet
2. Blue-drab shale, weathered buff on the surface
and containing a layer of sandstone 3 to 4 inches,
exposed 35 feet

The shale extends below the level of the creek, and the total thickness is unknown. On the northeast quarter of the northeast quarter of the same section, on a tributary of Troutman's Branch, about 25 feet of yellowish brown to drab shale are exposed above a four inch vein of coal, while beneath the coal is an eight foot layer of drab colored under-clay. Other exposures of shale occur along Troutman's Branch, but none were observed so large or so favorably situated for development as the ones above described.

A more compact form of blue shale has been quarried to some extent in section 5 (15 north, 6 west), for use in fire places, because of its fireproof qualities.

Along Lakey's Branch on the south half of section 33 (15 north, 7 west), occur a number of exposures of clay and shale. Several slope shafts to coal V have been opened in this vicinity. A general section along the branch as given by Ashley (1898 Report, p. 328), is as follows:

Section on Lakey's Branch.

	<i>Feet.</i>	<i>Inches.</i>
1. Limestone not seen in place.		
2. Light drab clay shale.....	8	0+
3. Coal V	2	6
4. Bone coal and pyrite.....	0	6
5. Light drab fire-clay.....	2	0
6. Gray shale, in places merging into thin beds of sandstone	15	0
7. Gray sandy shale.....	3	0
8. Bone coal	0	10
9. Black bituminous shale with streaks of coal...	9	0
10. Drab fire-clay with streaks of coal.....	1	0
11. Gray shale	3	0

Of the strata shown, Nos. 2, 5, 10 and 11, aggregating 14 feet in vertical thickness, can be made into clay products. Wherever the gray shale No. 6 does not carry too much silica it, also, can be used. If a mixture from it and the material from the other strata, is made, most of No. 6, as exposed, can be so used. The Central Indiana Railway passes within one-fourth of a mile of all these exposures.

On the Mary McAlister place, southwest of southwest of section 34, a 50 foot drilling is reported to have gone through four or five feet of coal at a depth of 33 feet, shale being encountered all the way to the coal. In the northwest of southeast of section 35, on the Jackson Nevins place, a section showed:

Section on Nevins Farm.

	<i>Feet.</i>	<i>Inches.</i>
1. Gray shale	3	0
2. Drab shale	6	0
3. Coal IV	5	4
4. Black shale	0	6
5. Shale, merging into gray shaly sandstone.....	6	6

The nine feet of shale above the coal can be used in making vitrified and ordinary brick.

Four and a half miles west of Rockville, along the stream known as Rocky Run, in the northwest quarter of section 3 and the northeast quarter of section 4 (15 north, 8 west), occurs a large deposit of exceedingly fine grained sandy clay known as "slip-clay." This is a natural glaze, of a highly fusible quality, which, when melted over the surface of stoneware gives to it a brilliant color and finish. The essential property of a slip-clay is low fusibility, for it must melt at a lower temperature than the clay used in the body of the ware, else the latter will not stand up under the heat required to melt the glaze. The best slip-clay in use among potters comes from Albany, New York, and costs, in small lots, about \$1.80 per barrel. To the ware made from the potters' clay found at Bloomingdale and Coke Oven Hollow this gives a brilliant, smooth, dark brown surface. The slip-clay from Rocky Run is used by the potters of western Indiana to glaze the inside of the ware. It gives a reddish-brown glaze, somewhat rougher than that produced by the Albany slip.

The Rocky Run slip-clay was analyzed by Dr. Levette* and its constituents found to be as follows:

Analysis of Rocky Run "Slip-Clay."

Silica (SiO_2)	55.20
Alumina (Al_2O_3)	14.40
<hr/>	
Clay base and sand.....	69.60
Ferric oxide (Fe_2O_3).....	9.40
Manganic oxide (MnO_2).....	1.80
Lime (CaO)	6.12
Magnesia (MgO}) .....	.90
Soda (Na_2O}) .....	.52
Sulphuric anhydride (SO_3).....	.34
<hr/>	
Fluxes	19.08
Moisture and volatile.....	8.60

Comparing with the last column of these figures the following average composition of the six slip-clays used in the leading potteries of Ohio,

*Report of the Geological Survey of Indiana, 1878, p. 159.

Clay base and sand.....	69
Fluxes	21
Moisture and volatile.....	9

we see that the Rocky Run clay possesses the necessary constituents of a successful natural glaze. As such it should be more thoroughly investigated by Indiana potters.

Along the bluffs of Big Raccoon Creek in Wabash Township are some of the leading clay deposits of Parke County. The most valuable of these, as far as variety, quality and accessibility of the clays are concerned, are found just east of Mecca, on the lands of the Mecca Coal and Mining Company, southeast quarter of section 20 and southeast quarter of the northwest quarter of section 20 (15 north, 8 west), where the following strata are exposed in a connected section beginning near shaft No. 2 of the Mecca Coal Company, and extending down the ravines to the mouth of Oklahoma Hollow, and in the shaft of No. 1 mine. Where the strata vary in thickness, the average, as near as ascertained, is given:

Section on Land of Mecca Coal and Mining Company.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil and drift "hard pan".....	6	0
2. Light blue sandy shale.....	27	0
3. Black bituminous shale.....	2	0
4. Coal VIa, double vein with thin fire-clay parting.	1	9
5. Under-clay, light gray.....	5	0
6. Blue shale	0	3
7. Coal VI	0 to 1	6
8. Yellow shaly sandstone.....	2	6
9. Drab to buff clayey shale.....	31	0
10. Dark sheety bituminous shale.....	1	0
11. Coal Vb	1	6
12. Under-clay, bluish gray.....	5	6
13. Soft, dark blue clayey shale.....	8	0
14. Dark fossiliferous limestone.....	0	6
15. Black sheety shale.....	2	0
16. Coal Va	1	2
17. Under-clay, dark shaly.....	1	8
18. Blue to light gray clayey shale.....	8	6
19. Dark bituminous shale with streak of coal at base	4	0
20. Under-clay, light gray.....	3	6
21. Sandy shale or "fake" in layers 2 to 4 inches thick	17	0

22. Dark bituminous shale.....	3	6
23. Coal IV	3	8
24. Under-clay, bluish gray.....	4	6
25. Dark bituminous shale.....	4	0
26. Coal III	5	8
27. Under-clay, merging into sandstone.....	2	6
<hr/>		<hr/>
Total	155	2

Outcrops of all the above strata, as far as No. 21, are visible along the sides of the ravines, as far down as the bottom of Oklahoma Hollow. The measurements of Nos. 21 to 27, inclusive, were obtained in the shaft of No. 1 mine.

Of the shales and under-clays, Nos. 2, 5, 9, 12, 13, 18, 20, 24 and 27, aggregating not less than 94 feet, and in places 107 feet in vertical thickness, occur in the area mentioned. Of these, the following are of such value as to be worthy of more extended mention:

The light blue shale (No. 2) is located by the side of the switch running to No. 2 coal shaft, and can be easily stripped and loaded directly into cars. It contains a large amount of free silica in fine grained particles. Three thin bands of kidney iron ore are found in the lower half of this stratum at intervals of two feet apart.

The bed of drab and buff clayey shale (No. 9) is a most valuable deposit. It is so situated that millions of tons can be loaded directly onto the switch running to coal shaft No. 1, or onto a short spur easily constructed. Sixty car loads of it were at one time shipped to Chicago Heights and used by the Ludowici Tile Company for making roofing tile. Samples have also been burned into red pressed front brick that can scarcely be equaled in quality or appearance.

The stratum of dark blue clayey shale (No. 13) is sometimes separated into two nearly equal beds by a layer of brown sandstone a foot to two feet in thickness. The shale has been practically tested in the making of paving brick, 75 or more car loads having at one time been shipped to the Indiana Paving Brick Company, of Brazil, and used for that purpose. The bricks from it were as tough and durable as any from the noted stratum of Brazil shale, to be described hereafter. No. 13 shale is softer and smoother to the sense of touch than any of those overlying

it in the section given. Near the bottom of this stratum are numerous nodules of kidney iron ore which can be readily thrown aside by the miner.

Analyses of average samples of each of these three shales were made by Dr. W. A. Noyes for this Department, their chemical constituents being found to be as follows:

Analyses of Carboniferous Shales from Land of Mecca Coal and Mining Company.

	No. 2. Per Cent.	No. 9. Per Cent.	No. 13. Per Cent.
Silica (SiO ₂)	59.77	58.83	59.02
Titanium oxide (TiO ₂) .....	.80	.70	1.10
Alumina (Al ₂ O ₃)	21.89	22.34	20.93
Water combined	4.53	5.22	7.59
Clay base and sand	85.70	87.09	88.64
Ferric oxide (Fe ₂ O ₃)	2.22	5.13	4.45
Ferrous oxide (FeO)	3.70	1.44	1.56
Lime (CaO) .....	.64	.49	.51
Magnesia (MgO)	1.98	1.56	1.66
Potash (K ₂ O)	3.10	4.18	2.92
Soda (Na ₂ O) .....	.85	.63	.41
Fluxes	12.49	13.43	11.51
Carbon dioxide (CO ₂) .....	.90	.....	.....
Totals	99.09	100.52	100.15

Although much more sandy in general appearance, the No. 2 shale is seen to contain less than one per cent. more silica than No. 9, and only .75 of one per cent. more than No. 13. However, the rational analysis of the three shales shows their clay substance to make up respectively, 63.22, 68.89 and 72.90 per cent. of their totals.

Comparing the percentages of clay base and sand and fluxes found in these shales with that of the standard,* we find their

	Standard. Per Cent.	No. 2. Per Cent.	No. 9. Per Cent.	No. 13. Per Cent.
Clay base and sand	84.78	85.70	87.09	88.64
Fluxes	13.22	12.49	13.43	11.51

chemical composition all that could be desired for the making of vitrified products. No. 2 will be found to be better suited for brickmaking than for sewer pipe or hollow brick, but the other two can be made into any desired form of vitrified material.

Quantities of the bluish-gray under-clay (No. 12), have, in the

* See page 82.

past, been shipped to the Northwestern Terra Cotta Works of Chicago and used as a body clay in the making of structural terra cotta. The upper part of the vein burns to a bright buff and the lower to a darker, almost tan color. Handsome pressed front brick of the latter tint, made from this deposit, are now in the State collection of Indiana clay products.

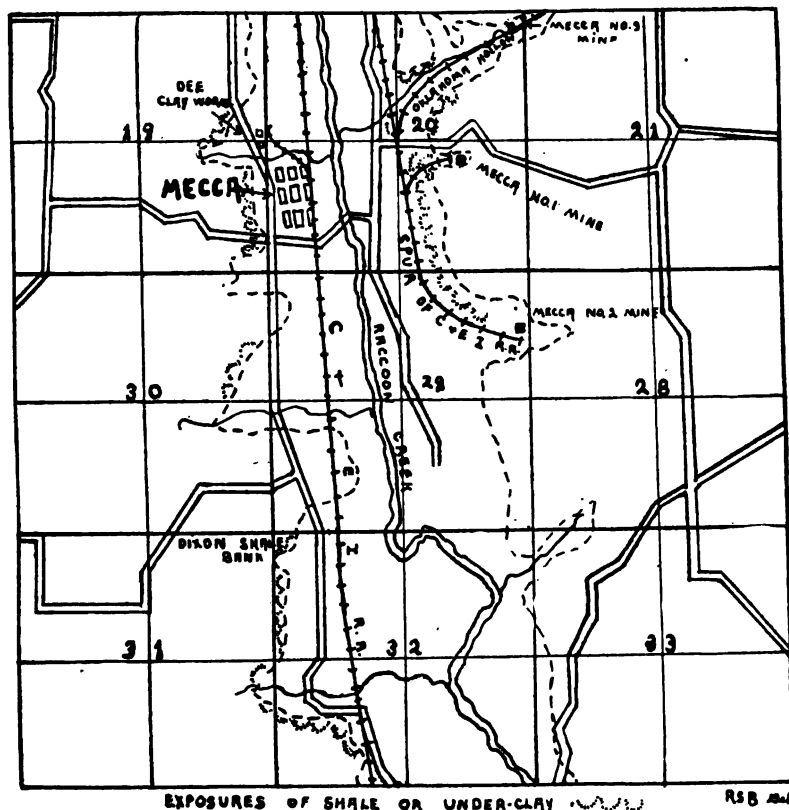


Fig. 3. Map of Mecca and vicinity, showing location of shale and clay deposits.

Under-clay No. 20, outcropping beneath the switch leading to coal shaft No. 1, is another valuable deposit. It is very soft and plastic where exposed, and so light colored that it is often used by miners for whitewashing. It burns to a handsome light buff, and a number of samples of high grade front brick have been made from it by the Cayuga Pressed Brick Company.

Under-clay No. 24 of the above section, found just below the

upper vein of worked coal, when first mined is a very hard, light gray clay, with fragments of stigmara and other plant remains scattered through it. When exposed it soon weathers into a soft, plastic material. It varies in thickness from two to five feet. Whenever coal IV comes down to within five feet of coal III, as it does in places, the whole interval is taken up with this under-clay. Where the distance between the two coals is greater than five feet, the lower portion of the interval is a dark bituminous shale. In the No. 1 mine, the interval as noted in the above section, is 13+ feet. In the new mine, No. 3 in Oklahoma Hollow, the two coals are 10 feet apart and the under-clay beneath the upper vein five feet thick. In some places the interval is as much as 16 feet.

The under-clay, No. 27, found beneath coal III, is a hard, dark gray clay, also with stigmara or plant remains. It runs only about two and a half feet in thickness when it merges into a dark gray sandstone.

Analyses of under-clays Nos. 12 and 20 were made for the 1895 clay report by Dr. Noyes, and those of Nos. 24 and 27 for this report by Dr. Lyons. The results of the four analyses are herewith given in one table for comparison:

Analyses of Under-Clays from Land of Mecca Coal and Mining Co.

	No. 12. Per Cent.	No. 20. Per Cent.	No. 24. Per Cent.	No. 27. Per Cent.
Silica (SiO_2).....	54.46	63.00	67.65	66.52
Titanium oxide (TiO_2).....	1.20	1.10	1.01	1.02
Alumina (Al_2O_3).....	25.71	23.57	19.97	20.12
Water combined.....	8.50	6.45	5.96	6.13
Clay base and sand.....	89.87	94.12	94.59	93.79
Ferric oxide (Fe_2O_3).....	5.51	1.87	0.72	1.03
Ferrous oxide (FeO).....	.91	.46	.....	.....
Lime (CaO).....	.34	.44	0.48	0.83
Magnesia (MgO).....	.83	.39	0.59	0.89
Potash (K_2O).....	2.68	2.40	1.75	3.05
Soda (Na_2O).....	.33	.29	2.29	2.57
Fluxes.....	10.50	6.35	5.83	6.17
Totals.....	100.37	100.47	100.42	99.96

The analyses show that no one of the four under-clays is, properly speaking, a refractory or "fire-clay," i. e., a clay which will make high grade refractory products, such as furnace brick, glass pots, gas retorts, etc. To make such products the clay

should run as high as 96 per cent. clay base and sand, and not over four per cent. fluxes. Clay No. 24, from beneath coal IV, is the most refractory of the lot. It would serve well as a bond clay for non-plastic, refractory clays, such as the kaolinite of Lawrence and Martin counties or the "fire-clay" of West Montezuma.

All the above under-clays are, however, well suited for the making of sewer pipe, hollow brick, conduits, flue linings, terra cotta, pressed front brick, etc. Nos. 20, 24 and 27 can also be made into stoneware.

The Mecca Coal and Mining Company mines, from the land on which the above clays are found, coals III and IV which, in this region, are semi-block coals. As a fuel either for domestic or manufacturing purposes they take rank among Indiana coals second only to "Brazil Block." At Veedersburg and Montezuma and at the Dee Sewer Pipe Plant at West Mecca, where these coals have long been used in the making of paving and fire-brick and sewer pipe, they are pronounced the best fuel which can be secured for burning these products. Running to each of the coal shafts, and passing by the side of the main strata of shales and fire-clays, are switches of the C. & E. I. Railway. Raccoon Creek, with a never-failing supply of water, is within one-eighth of a mile of the leading deposits. With an unlimited supply, in great variety, of the better grades of shales and fire-clays, with good transportation facilities already constructed, and with excellent fuel and plenty of water—all in one place—this is the most eligible location for a great clay industry which Parke County possesses. Indeed, few better can be found in the State.

On the western bluffs of Big Raccoon Creek similar deposits occur but, while extensive, they are not of so great variety. The Wm. E. Dee Clay and Manufacturing Company, of Chicago, owns a large tract in the southeast quarter of section 19, and at the foot of the bluffs is operating two large sewer pipe factories, one of which was erected in 1895, the other in 1904. Combined, they form the largest clay industry in the State. Since 1895, the town of Mecca, now containing 1,200 population, has come into existence at this point.

On the bluff just west of the sewer pipe plants Mr. Dee sunk a test shaft 6x6 feet in size, which disclosed the following strata:

Section of Test Shaft on Dee Land at Mecca.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil and yellow clay.....	8	6
2. Coal VI	1	2
3. Under-clay	4	6
4. Gray to blue clayey shale.....	41	4
5. Coal Vb	1	6
6. Under-clay	9	0

Nos. 3, 4 and 6 of the section are used in the two factories, the shale being mainly used in the old one in making sewer pipe, and the under-clays in the new one in the making of hollow brick, flue linings, etc. No less than 1,452 car loads of material, valued at \$171,271 were made at the old factory alone in 1903. The pit from which the shale for this pipe is gotten is located about 150 yards west of the factory on the slope of the bluff, the shale, when blasted down, being hauled in carts by horsepower to the plant. Ten men are worked in the pit. A fine grade of coal, costing \$1.72 per ton, laid down, is secured from the Mecca Coal and Mining Company's No. 3 plant, a mile northeast. There is little doubt but that both No. IV and No. III coal of workable thickness would be found beneath the Dee Company's tract, should a shaft be sunk to their levels. Water is secured from Raccoon Creek, a few hundred yards east of the plants. Having here the four great necessary factors, viz., raw materials, transportation, cheap fuel and a plentiful water supply, the Dee Company's success was assured from the start. From a small beginning in 1895 it has grown gradually into one of the greatest industries of western Indiana.

The bluff west of the town of Mecca extends north about two miles and south-southeast to Rosedale and beyond the county line. It forms the eastern side of a narrow ridge or tongue of high land, underlain by coal VI, which extends northward into the angle formed by the junction of Raccoon Creek and the Wabash River. West of Mecca this ridge is but about one and a fourth miles wide and 100 or more feet above the lowlands bordering the two streams. The bed of shale worked by Dee at Mecca extends clear across this ridge and on the western side outcrops with a 25 foot exposure in the northwest corner of section 25 (15 north, 9 west), near the junction of the Mecca-Clinton and river roads.

The Marion Brick Company, of Indianapolis, operating at Montezuma and Marion two of the largest ordinary brick plants in the State, recently purchased from S. Dixon, 36 acres of land one and a fourth miles south of Mecca in the northwest of the northwest quarter of section 32 (15 north, 8 west). This land corners on the C. & E. I. Railway and, for the most part, is included in the upland or eastern side of the ridge above mentioned. In a narrow ravine extending back from the lowland near the railway into the ridge, a fine bed of dove-colored clayey shale outcrops with an exposure of 30 feet, with only two or three feet of overlying surface. Beneath the shale is a 20 inch vein of coal overlying five feet of under-clay. This under-clay merges into a stratum of shaly sandstone two or three feet in thickness, which forms the roof of coal VI, here three feet six inches thick. Underlying coal VI is a vein of under-clay, three to five feet thick, which is said to be a superior potters' clay. The Marion Brick Company paid but \$70 an acre for the land, including all these resources, and will soon erect a large plant on the low ground next to the railway to utilize the various clay materials.

South of the Dixon farm, on the lands of Mrs. S. C. Pruett, Freeman Cox and George Laverty, in sections 32 (15 north, 8 west), and 5 and 6 (14 north, 8 west), the same shales and under-clays are found in profusion. The C. & E. I. Railway either skirts or runs through these lands and furnishes an excellent outlet to Chicago and other northern points, while the T., H. & L. is but a few miles to the southeast. There is little doubt but that this valley of the Raccoon between Mecca and Coxville will, in a few years, be the seat of numerous and important clay industries.

Township 14 North, Ranges 6, 7, 8 and 9 West.

Beds of under-clay, beneath coal I, suitable for terra cotta or sewer pipe, are exposed in the northwest quarter of section 4, and in the northwest and southeast quarters of section 14 (14 north, 6 west).

On the south bluff of Otter Creek, northeast quarter of section 36 (14 north, 7 west), a mile and a half northwest of Carbon,

and one-half mile east of the Central Indiana Railway, is an exposure of shale 17 feet thick. The upper nine feet is a soft, grayish-blue material free from grit and seemingly of excellent quality for all kinds of vitrified products. The lower eight feet contains more silica and will be found better fitted for ordinary brick. The bottom of the bed is hidden, and its thickness at this point is therefore unknown. Otter Creek furnishes an abundant supply of water. Coal III, averaging about three feet three inches in thickness, occurs in this region, and will probably be found from 10 to 18 feet below the level of Otter Creek at the point mentioned, with a bed of under-clay beneath. But one or two feet of stripping would be necessary to get at the top of the shale.

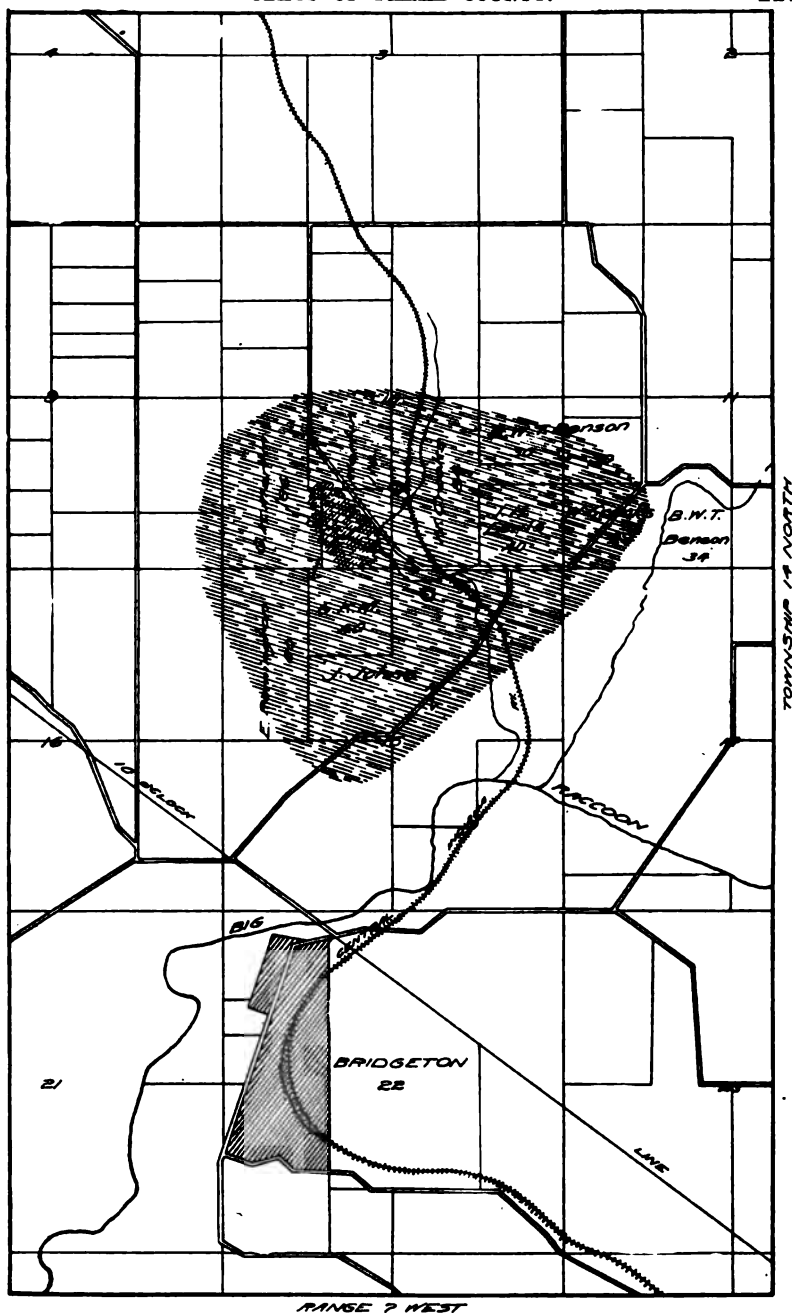
This same bed of shale outcrops along Otter Creek in various places in sections 31 and 32 above the point mentioned. A spur of the Big Four Railway runs out to several mines in section 32. By the side of the spur, on the land of Joseph Dalton, in the southwest quarter of that section, a bed of drab clay shale 6+ feet thick occurs just over coal IV, which is here four feet three inches thick, with a bed of under-clay three and a half feet thick beneath it. Much of the coal has been worked out from beneath this region.

One mile north of Bridgeton, on the land of John Johns, northwest quarter of the northeast quarter of section 15 (14 north, 7 west), and within 100 yards of the Central Indiana Railway, a slope shaft has been put into the side of a bluff to mine coal IV. On the side of the hill, at the mouth of the shaft, the following section is exposed:

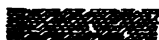
Section on Johns Farm, North of Bridgeton.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil and surface clay.....	0	8
2. Buff to drab clayey shale.....	22	0
3. Coal IV	2	5
4. Bone coal	1	0
5. Under-clay	6	0

The shale No. 2, where exposed, had weathered into a soft, plastic clay, having every appearance of a good vitrifying material. The under-clay, No. 5, was of a light gray color, very free from impurities, and weathered on the exposed face into fine



Shale



Extra shale



Coal slope

a Bridgeton and vicinity, showing location of shale deposits.

quadrangular pieces, indicative of its superior quality. Where wet, it was exceedingly plastic, and it can, without doubt, be made into the best of hollow brick, sewer pipe, flue linings and kindred products, also into stoneware.

An area of 160 acres south of the shaft opening is, without doubt, underlain with the same shale and clay. Water in abundance can be secured from Raccoon Creek, one-half mile distant, and with a railway already in place, this tract offers an excellent site for a large clay industry.

Along a small stream leading northwest from the Johns opening, the same stratum of shale outcrops for one-half mile or more, in places 20 to 25 feet thick. One of the best exposures is on the L. Martin farm in the southwest quarter of section 10 (14 north, 7 west), where the shale has been removed to make room for a roadway.

Just west of this, on the G. K. Martin land, west half of the southwest quarter of section 10, coal IV was being stripped along a branch in October, 1904. The section exposed showed:

Section on G. K. Martin Farm, North of Bridgeton, Ind.

	<i>Feet.</i>	<i>Inches.</i>
1. Alluvial surface soil and clay.....	3	0
2. Shale	2	10
3. Coal IV	2	4
4. Under-clay	1+	0

The shale stratum, 20 feet thick, occurs near the surface over 200 or more acres in the upland just to the south and west, while the under-clay, three and a half to four feet thick, is exposed in several places 150 yards farther down the stream. A bore put down on the G. K. Martin land, northeast of northwest of section 15, passed through the following strata:

Section of Bore No. 4 on G. K. Martin Land.

	<i>Feet.</i>
1. Surface clay	4
2. Light drab to buff shale.....	33
3. Blue shale	4
4. Coal IV	3
5. Under-clay	4
6. Sand rock	38
7. Lime rock	9
8. Coal III	4

One-half mile southeast of Minshall, in the northwest quarter of section 17 (14 north, 7 west), a bore put down near shaft No. 7, disclosed the presence of the following underlying strata:

Record of Bore Near Shaft No. 7, Southeast of Minshall.

	<i>Feet.</i>	<i>Inches.</i>
1. Surface	4	0
2. Fire-clay	3	0
3. Black shale	8	0
4. Coal	1	6
5. Fire-clay	4	6
6. Black shale	2	6
7. Blue limestone	3	0
8. Light clay shale.....	9	6
9. Gray shale	24	0
10. Dark blue shale.....	23	6
11. Coal	0	6
12. Fire-clay	3	6
13. Black shale, coal mixed.....	2	0
14. Fire-clay	4	6
15. Black shale	9	0
16. Coal	0	6
17. Fire-clay	4	0

This bore showed the presence in that vicinity of 76½ feet of shale and under-clays, embraced in Nos. 2, 5, 8, 9, 10, 12, 14 and 17 of the above section. This* out of a total of 107½ feet shows a plentiful supply of clay working materials. Switches from the T. H. & L. Railway are already in place and coal in abundance is mined within one-half mile.

In the vicinity of Caseyville, near the Clay County line, thick deposits of both shale and fire-clay have been exposed in mining the block coal No. IV. Switches from three railroads penetrate this region and give abundant facilities for shipping. At the Superior No. 2 mine, southwest quarter of section 35 (14 north, 7 west), operated by Zeller, McClelland & Co., of Brazil, the following section was obtained from the shaft:

Section of Superior No. 2 Shaft.

	<i>Feet.</i>	<i>Inches.</i>
1. Surface	60	0
2. Black shale	7	0
3. Coal V	4	6
4. Under-clay	5	0
5. Shale	15	0
6. Coal IV	4	4
7. Under-clay	4	6

The shale No. 5 is a dark blue, clayey material, while the under-clay, No. 7, is a fine quality of dark gray plastic fire-clay, similar to that of the same horizon which is used so extensively at Brazil. Much of this under-clay has, in the past, been loaded for shipment to Chicago, there to be made into terra cotta. It brought 45 cents a ton at the mine. As some of it had to be taken up to make height in the rooms and entries, a fair profit was realized at this price. Thousands of tons of it, mixed with other useless materials, have gone to waste on the dump.

In the Coxville-Rosedale area, southwest quarter of township 14 north, 8 west, a general section, as given by Ashley,* shows the first 50 feet as follows:

General Section in Coxville-Rosedale Area.

	<i>Feet.</i>	<i>Inches.</i>
1. Surface	1	0
2. Under-clay	7	0
3. Sandstone	5	6
4. Drab shale	0	6
5. Coal VI	5	0
6. Under-clay	4	0
7. Light gray clayey shale.....	20	0
8. Drab shale	1	0
9. Coal Vb	0	10
10. Under-clay	0	6

The shale, No. 7, and the under-clay, No. 6, are the same strata as are used so extensively at the Dee sewer pipe works at Mecca; the shale occurring between coals VI and Vb, and the under-clay below the former over a large area in southwestern Parke County.

At the No. 6 shaft of the Parke County Coal Company, in the northwest quarter of section 27 (14 north, 8 west), a bed of shale 53 feet thick was encountered after passing through 10 feet of overlying drift material. The greater part of this was suitable for manufacturing purposes. The fire-clay beneath the worked vein of coal (No. VI) runs from four to six feet in thickness in the region, and merges into sandstone.

Northwest of Coxville, in the area between Irons and Little Raccoon creeks, are some excellent deposits of shale and under-clay. One of these, on the land of W. W. Ray, west half of sec-

*Twenty-third Ann. Rep. Ind. Dept. Geol. & Nat. Res., 1898, 381.

tion 15 (14 north, 8 west), is on a spur of the T. H. & L. Railway. Coal VI is here four and a half feet thick, with 18 feet of a fine quality of shale above it and four to nine feet of under-clay below it. A sample of this under-clay, analyzed by Dr. Noyes, showed the following chemical composition:

Analysis of Under-Clay from Land of W. W. Ray.

	<i>Per Cent.</i>
Silica (SiO_2)	53.91
Titanium oxide (TiO_2)	1.60
Alumina (Al_2O_3)	26.18
Water combined	7.99
<hr/>	
Clay base and sand	89.68
Ferric oxide (Fe_2O_3)	3.39
Ferrous oxide (FeO)	1.25
Lime (CaO}) .....	.30
Magnesia (MgO}) .....	.95
Potash (K_2O)	3.60
Soda (Na_2O}) .....	.44
<hr/>	
Fluxes	9.93
Carbon dioxide (CO_2) .....	.25
<hr/>	
Total	99.86

The analysis proves the chemical fitness of the clay for making all kinds of vitrified products, and especially sewer pipe, hollow brick, flue-linings, chimney tops, etc. Combined with the overlying shale, it will make a good vitrified brick. It will also burn into a handsome dry pressed front building brick.

A burned sample of the overlying shale furnished me by Supt. F. T. Hatch, of the Vandalia Railway, shows that its vitrifying qualities are perfect. With good railway facilities, plenty of water, and an abundance of coal, all present, this deposit of shale and under-clay offers exceptional advantages to any one seeking a site for a new clay industry.

One mile northwest, on the J. P. Cornelius farm, east side of section 9 (14 north, 8 west), coal VIa outcrops with six feet of fine under-clay beneath it. Both shales and fire-clays abound on both sides of the high ridge extending between Irons and Racoon creeks, from near Coxville to and above Mecca.

In the Lyford No. 2 coal shaft, west half of section 13 (14 north, 9 west), the upper 50 feet of a section shows:

Part of Section of Lyford No. 2 Shaft.

	<i>Feet.</i>	<i>Inches.</i>
1. Surface (in shaft)	8	6
2. Blue shale	31	0
3. Gray shale	11	6

Coal VI, six and a half feet in thickness, is worked at a depth of 143 feet, with six feet ten inches of a fine quality of a very plastic under-clay below it. Railway switches are already in place and water in abundance can be obtained from the Wabash River, less than one mile to the west.

The southern portion of Parke County extends beyond the limits of the Wisconsin drift sheet, and its surface is covered with a nearly pebbleless white clay several feet in thickness, which rests upon a sheet of older or Illinoian drift. The central and northern portions of the county, and a narrow belt along the Wabash, in the southern portion, are covered by the later sheet of till. Wells are often obtained at the junction of the two drift sheets at depths of 20 to 40 feet on plane tracts, and somewhat greater depths on the moraines or drift ridges.

The surface clays are used only at Bellmore, where about 36 inches of a swamp deposit are made into drain tile. At Rockville wells reach the bottom of the newer drift at about 25 feet. A sample of a yellow surface clay from near Rockville was analyzed by T. W. Smith, and its composition found to be:

Analysis of Surface Drift Clay from Rockville.

Silica (SiO_2)	66.84
Alumina (Al_2O_3)	13.64
Water combined	4.22
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Clay base and sand.....	84.70
Ferric oxide (Fe_2O_3).....	9.40
Lime (CaO)	1.36
Magnesia (MgO)	trace
Potash (K_2O)64
Soda (Na_2O)	3.34
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Fluxes	14.74
<hr/>	
Total	99.44

The analysis proves the chemical fitness of the clay for ordinary brick and drain tile. The percentage of iron is too high for vitrified wares.

From what has been said it may be seen that Parke County abounds in clays suitable for ordinary and pressed front brick, terra cotta, roofing tile, sewer and drain pipe, paving brick, stoneware and refractory products. Only the larger and more notable deposits have been mentioned in the foregoing pages. Many others of as good quality doubtless occur. These rich resources are as yet practically undeveloped. Aside from a few small stoneware potteries and brick yards, supplying a local trade, there are but three factories for making clay products located in the county, viz., the Wm. E. Dee plant at Mecca, and the plants of the Marion Brick and National Drain Tile companies at East Montezuma. These have been started since the former clay report was issued, and have met with unqualified success in all their operations. They are but the forerunners of others to come, for the raw material is there, the fuel in abundance to burn it is there, four railroads pass entirely through the county, and two others touch its borders, all ready to carry the completed products to the four quarters of the globe. With these facilities present, capital in time will come, will be invested, and will make the county a great clay industrial center.

VERMILLION COUNTY.

This county lies on the western edge of the center of the State, just south of Warren, west of Fountain and Parke and north of Vigo County. Its eastern boundary is the Wabash River, and its western the Illinois State line. It comprises a strip of territory whose maximum length is $37\frac{1}{2}$ miles, and average width a little less than seven miles; its area being 255 square miles.

The Coal Measure rocks of the Carboniferous Period form the surface of the entire county with the exception of a very narrow strip along the west bank of the Wabash in the northern fourth, where the Mansfield sandstone of the same period is exposed. The river here flows through a narrow valley cut in the sandstone, which outcrops at frequent intervals in a ledge rising 30 to 50 feet above the river from Jordan Creek north to the north-

ern boundary. South of Jordan Creek the sandstone ceases and a clay and gravel terrace, flanked by low bluffs on the west, continues to the Big Vermillion Valley.

The Wabash River on the east forms the drainage level of the county, receiving from the west all streams which drain its area. These, named in order from north to south are, Spring Creek, Jordan Creek, Big and Little Vermillion rivers, Raccoon Creek, Norton's Creek, Feather Creek and Brouillett's Creek.

About one-third of the area of the county is taken up by the terraces and lowland bottoms of the Wabash and its tributaries. Between the Big and Little Vermillion rivers the Wabash bottom land reaches its extreme breadth of 2.5 to 3.5 miles. From a point two miles south of Hillsdale northward for six miles, or nearly to Newport, the county seat, the bluffs are high and close to the river, so that the small tributaries serrating the front of the bluff yield numerous good exposures of the Coal Measure Rocks. Below the point mentioned, the bluffs swing off to the southwest, leaving a wide terrace of sand, gravel and clay, principally comprised in Helt's prairie, which rises about 40 feet above the river. In the southern part of the county the bluffs are one or two miles from the river, and rise 100 to 135 feet above low water mark. The upland area of the county is, in general, a high, flat, prairie like country, forming, in the main, a rich agricultural region. This area is cut through by the Big and Little Vermillion rivers and Brouillett's Creek, the two former having cut down to the base level of the Wabash. The most broken part of the county is probably along the Big Vermillion, the banks of which rise 100 to 140 feet above low water mark in the Wabash.

Along the bluffs of the Wabash and other streams, at the point where they meet their terraces, the largest and most available deposits of under-clays and shales found in the county are exposed. The Chicago and Eastern Illinois Railway, running north and south the full length of the county, and close to its eastern border, has its road bed within a mile and a half of nearly all of the principal clay exposures. Two other railways, the Toledo, St. Louis & Kansas City, and the Springfield Division of the C., H. & D., cross the county from east to west; the former across

the south border of the northern third, and the latter, south of the center. In addition to these, the Peoria Division of the Big Four touches the northwestern corner, while a Chicago extension of the Southern Indiana, now in course of construction, will run north and south through the western portion of the southern half; so that the transportation facilities are of the best.

Townships 19 and 18 North, Ranges 9 and 10 West.

No personal examination was made of the clays of this area. A section at Perrysville, northeast quarter of section 33 (19 north, 9 west), given by F. H. Bradley* records coal VI, 8 to 18 inches in thickness, as occurring close to the surface, with two feet of under-clay and 12 to 15 feet of soft blue clay shale immediately below. Drilling to a depth of over 100 feet failed to disclose another vein of coal, but several beds of black, shaly, calcareous clay were encountered.

Along Spring Creek, in the southeast of the southwest of section 10 (19 north, 9 west), there is an exposure of 18 feet of blue clay shale; while in the southeast of the northeast of 9 six feet of the same material outcrops on the north bank of the creek.

But few deposits of workable shale or clay are exposed in township 18 north, 9 west, outcrops above the coals being usually a shaly sandstone or a soft black shale. According to Ashley, "probably all of 18 north, 10 west, is underlain by coal VI and coal VIa which, over much of that area, may be presumed to be workable, since they appear to be workable wherever exposed or pierced with the drill. To work both of them the intervening clay should be marketed, tests having shown it to be very suitable for brick. This coal occurs about at drainage level in the southern part of the township, but becoming 60 or 70 feet below the shallow cutting streams in the northern part."

A section on the Brand farm, southeast of southeast of section 20, shows:

*First Ann. Rep. State Geol. Ind., 1869, 158.

Section of Drilling on Brand Farm.

	<i>Fect.</i>	<i>Inches.</i>
1. Loam	4	8
2. Clay	5	0
3. Under-clay	8	0
4. Black shale	6	0
5. Coal VI	5	0
6. Under-clay	6	0
7. Coal Vb	1	8
8. Under-clay	3	0
9. Sandstone	5	0
10. Metalliferous sand shale.....	11	0
11. Under-clay	5	0
12. Coal Va	1	2
13. Soapstone	13	0

Of the strata given, Nos. 2, 3, 6, 8, 11 and 13, aggregating 40 out of a total of 74½ feet, are suitable for many kinds of clay wares.

Township 17 North, Ranges 9 and 10 West.

Between Cayuga and Newport the Wabash River flows in a southeasterly direction and its terrace or second bottom widens out until, in places it is nearly four miles in width, with an average elevation of almost 40 feet above the overflowed bottom land. Along the western border of this terrace or prairie the outcrops of shale and clay, with their accompanying coals, occur in many places. But one of these has been utilized, and that by the Acme Brick Works and the Cayuga Brick and Coal Company, in the northeast quarter of section 7 (17 north, 9 west), on a spur of the Clover Leaf Railway. The first named company purchased 25 acres of bluff or upland, one mile southwest of Cayuga, and began the making of ordinary brick in the spring of 1904. A section of their pit in July showed:

Section of Pit at Acme Brick Works.

	<i>Fect.</i>	<i>Inches.</i>
1. Soil and yellow clay.....	10	0
2. Pinkish shaly sandstone	1	8
3. Bluish gray clayey shale.....	18	0
4. Dark blue under-clay.....	7	0

The yellow clay, No. 1, is of glacial origin, but is almost free from lime pebbles and other harmful impurities. The shale, No. 3, is of excellent quality, being soft, unctuous and free from

grit. No. 4 is peculiar in that, while much darker in color than the overlying shale, it burns to a buff or creamy white. The coal vein belonging between Nos. 3 and 4 has evidently run out before reaching the locality of the pit. All the above strata are mixed and used, from 60 to 75 cars, holding one and a half cubic yards each, being taken from the pit each day to make 35,000 ordinary brick.

A bore sunk from the bottom of a ravine on the company's land a short distance southwest of the pit showed:

Section of Bore on Land of Acme Brick Works.

	<i>Feet.</i>	<i>Inches.</i>
1. Sandstone	1	0
2. Light gray clayey shale.....	24	0
3. Shaly sand rock.....	20	0
4. Under-clay	3	0
5. Gray shale	8	0
6. Under-clay	1	3
7. Coal	2	6
8. Under-clay	0	11
9. Coal	2	6

It is the intention, in time, to sink a shaft to the coals, Nos. 7 and 9, and mine both them and the separating band of under-clay. The raw materials at hand give every assurance of a successful future to the industry.

One-third of a mile south, on the same section, is located the plant, coal shaft and clay pit of the Cayuga Brick and Coal Company. A section in that portion of the pit being worked in July, 1904, showed:

Section of Clay Pit of Cayuga Brick and Coal Company.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil and surface clay.....	4	0
2. Soft pinkish brown shaly sandstone.....	11	0
3. Drab to gray sandy shale.....	18	0
4. Traces of coal VIb.....	0	$\frac{1}{2}$
5. Dark blue under-clay.....	6	0

The soil and shaly sandstone, Nos. 1 and 2, 12 to 19 feet in thickness, are stripped, necessitating a heavy expense to get at the underlying strata. The sandstone, No. 2, merges gradually into the shale, No. 3, so that the upper portion of the latter contains a large quantity of free silica and numerous scales of mica;

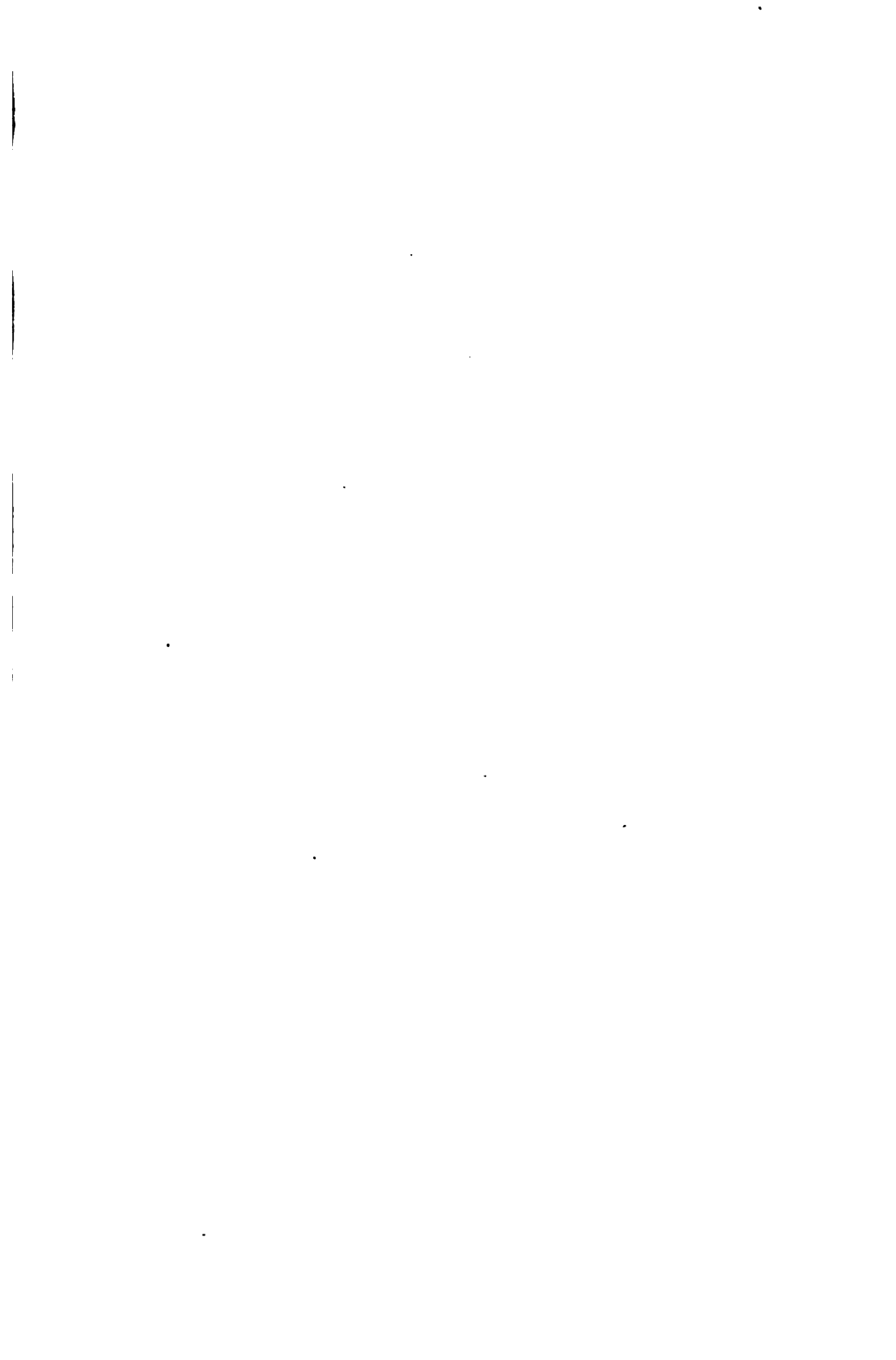
not enough, however, to prove harmful. The upper and lower portions of the shale stratum were formerly mixed together in varying proportions to form different shades of red dry pressed front brick. Average samples, taken from the centers of several unburned brick, which were made of a mixture, were analyzed by Professor Noyes for the 1895 clay report, and the composition found to be:

Analysis of Shales Used by the Cayuga Brick and Coal Company.

Silica (SiO_2)	65.78
Titanium oxide (TiO_2).....	1.00
Alumina (Al_2O_3)	14.79
Water combined	4.98
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Clay base and sand.....	86.55
Ferric oxide (Fe_2O_3).....	8.03
Lime (CaO)54
Magnesia (MgO)	1.42
Potash (K_2O)	2.82
Soda (Na_2O)97
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Fluxes	13.78
Carbon dioxide (CO_2).....	.26
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Total	100.59

The mixture burned into a tough, even grained, front brick of a handsome and uniform shade of red. Its composition shows it to be well suited for the making of vitrified products. In 1902 the company abandoned the dry pressed process and began making a stiff mud facing brick from the same material. These brick are burned in Eudaly kilns and come out a handsome dark cherry red in color. The average output of the factory is about 50,000 per day for 10 months of the year. For these it takes 110 cars of shale from the pit, the cars being hauled by steam power up an inclined tramway and dumped automatically near the dry pans.

Stratum No. 5 of the section given has the general appearance of an under-clay, being un laminated, but is of a darker color than is usually possessed by such deposits. The trace of coal above it is additional proof that it is an under-clay and not a shale. In the shaft of the mine, just west of the clay pit, it was 7 feet thick and was mined from there for some years for brick-





Shale Pit of Cayuga Brick & Coal Co., Cayuga, Vermillion County. •



Shale Pit of Newport Brick & Clay Co., Newport, Vermillion County.

making purposes. Its chemical analysis proved it, however, to be of low refractory power. Prof. Noyes analyzed an average sample and found its composition to be as follows:

Analysis of Under-Clay from Pit of Cayuga Brick Company.

Silica (SiO_2)	55.09
Titanium oxide (TiO_2).....	1.20
Alumina (Al_2O_3)	20.76
Water combined	7.01
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Clay base and sand.....	84.06
Ferric oxide (Fe_2O_3).....	3.00
Ferrous oxide (FeO).....	4.01
Lime (CaO)	1.51
Magnesia (MgO)	1.18
Potash (K_2O)	2.36
Soda (Na_2O}) .....	.34
<hr/>	
Fluxes	12.40
Carbon dioxide (CO_2).....	3.04
<hr/>	
Total	99.50

This clay burns into a buff front brick of handsome appearance. Just why it should burn buff when the analysis shows the presence of 7.01 per cent. of iron oxide, is a chemical problem which is difficult to solve. The large amount of carbon-dioxide present shows that the dark color of the unburned clay is due, in part, to organic matter. At the exposure west of the plant of this company the layer of sandstone overlying the shale is much thinner, and the latter is seen to have a strong dip to the southwest and to be much contorted in the bed. One-half mile south the shale has been proven by bore to be 30 feet thick, with a surface stripping of but two and a half feet.

The coal mined by the Cayuga Brick and Coal Co., is probably coal VI, and runs about five feet in thickness. Above it is a thick stratum of a soft clayey shale, with many kidney iron concretions or "boulders" scattered through it. Beneath the coal is 7 to 13 feet of under-clay, which, however, is said by the mine superintendent to be rather poor in quality.

Near the southeastern limits of the town of Newport, north-east quarter of section 35 (17 north, 9 west), the Newport Brick and Clay Stock Company purchased seven acres of land for

\$2,000, and erected a plant in 1903 for the purpose of making ordinary brick from a bed of shale which there outcrops. In July, 1904, the company was making 30,000 brick a day. Their plant is located on a switch of the C. & E. I. Railway, 300 yards below the station at Newport. A section of the pit, located 150 feet south of the plant, showed as follows:

Section of Clay Pit at Newport.

	<i>Feet.</i>	<i>Inches.</i>
1. Surface soil and clay.....	2	0
2. Soft drab to blue clayey shale.....	24	0
3. Coal VIa	1	3
4. Under-clay	6+	0

The pit is located on the edge of a gradual slope of the Wabash River bluffs, which extend from this point close along the river to below Hillsdale, and embody some of the best clay deposits of the State. The shale, No. 2 of the section, is a soft, fine grained material, which can be burned into many higher grade products than ordinary building brick. It lies within six feet of the surface beneath the terrace on which the plant of the company is located, having been struck when digging the pit for the dry pan. A well 33 feet deep, sunk near the factory, failed to reach the bottom of shale and under-clay deposits, and water is obtained from the Little Vermillion River, 1,300 feet to the north.

This shale deposit underlies the town of Newport, within three to seven feet of the surface. It will be found close to the surface all along the slope or ridge rising from the terrace on the south side of the town. A portion of this slope lies within the town limits, and fine sites for several large clay industries are available along its edges.

Along the Little Vermillion River, three and a half to five miles west of Newport, and five miles north of Dana, are some excellent outcrops of shale and under-clay suitable for many kinds of clay products. On the land of Daniel Nichols, north-west quarter of section 31 (17 north, 9 west), is a bluff of light gray clayey shale on the south bank of the river, 35 feet thick and one-fourth of a mile long. The talus along the foot of this bluff, formed from the weathered particles of shale, is a fine-grained, very plastic clay, and the whole deposit will be found suitable for all kinds of vitrified wares. A terrace just opposite,

on the north side of the river, has its level just above high water mark, and furnishes an excellent factory site. This point is one and a half miles east of the Chicago extension of the Southern Indiana Railway, and about three and a half miles south of the Clover Leaf Railway. Water in abundance occurs in the river at the foot of the bluff, and a good quality of coal is mined within a quarter of a mile. Coals VI and V, of a good workable thickness, will probably be found below the level of the river. With a railway spur in place this would be an ideal spot for a great clay industry. Without it, the shale deposit has no value. The same bed of shale outcrops in the ravines, northwest quarter of section 4 (16 north, 10 west), leading back from the south bank of the Little Vermillion for a half mile or more as one ascends the stream.

On the land of the James Fletcher estate, southwest quarter of section 33 (17 north, 10 west), the shale is exposed in another bold bluff 800 feet long, on the south side of the river; 28 feet in vertical thickness, showing above the water level. Overlying the shale at this point is three feet of grayish sandstone and about two feet of surface clay. The shale is here soft, unctuous, easily weathered and of excellent quality. This point is about one and a quarter miles east of the Chicago and Southern Indiana and three miles south of the Clover Leaf Railway.

Coal VII is worked at a number of slope shafts across the river from this point, averaging four feet eight inches in thickness, with 18 inches of under-clay beneath. Drillings in this region have shown coal VI, five and a half to six feet thick, to be 85 feet below VII.

Farther up Little Vermillion, in the vicinity of the "Horse-shoe Bend," southwest quarter of section 29, and southeast quarter of section 30 (17 north, 10 west), are other exposures of shale and under-clay which will be valuable whenever a spur from a railway enters the region. A connected section along the Little Vermillion from the Horse-shoe Bend to the old White's Mill ford, as secured by Kindle for the 1898 report, showed the following strata in place:

Section on Little Vermillion River.

	<i>Feet.</i>	<i>Inches.</i>	<i>Feet.</i>	<i>Inches.</i>
1. Fire-clay.				
2. Coal VIIa	3	3	3	3
3. Fire-Clay	12	0	15	3
4. Black bituminous clay	0	6	15	9
5. Soft black shale.....	0	6	10	3
6. Coal VII	4	6	20	9
7. Fire-clay	1	6	22	3
8. Limestone, hard, blue, fossiliferous	1	6	23	9
9. Shale, bluish gray with fossils...	7	0	30	9
10. Shelly sandstone	3	0	33	9
11. Bluish gray clay shale.....	35	0	68	9
12. Limestone, hard, ferruginous and black	1	0	66	9
13. Tough black sheety shale.....	0	10	67	7
14. Soft black shale.....	0	6	68	1
15. Coal VIIb	0	6 to 8	68	9
16. Shelly sandstone	5	0	73	9

Nos. 1 to 4 of the section occur only in the vicinity of the Horseshoe. No. 11 represents the shale beds above described. Coal VI will be found below drainage over most of the area. Between it and VIIb will usually be found about four feet of under-clay suitable for manufacturing.

Township 16 North, Ranges 9 and 10 West.

Along the bluffs of the Wabash River, between Hillsdale and Newport, in township 16 north, 9 west, occur some of the best clay deposits in the State of Indiana.

In a ravine on the land of Burns & Hancock, southwest quarter of section 26 (16 north, 9 west), a short distance west of the station of Montezuma, the following connected section was obtained, which shows the presence of a remarkable variety and quantity of high grade commercial clays:

Section on Burns & Hancock Land, West Montezuma.

	<i>Feet.</i>	<i>Inches.</i>	<i>Feet.</i>	<i>Inches.</i>
1. Soil and drift.....	5 to 7	0	7	0
2. Sandstone	2 to 10	0	17	0
3. Light gray sandy shale.....	1 to 6	0	23	0
4. Coal VII	3 to 5	6	28	6
5. Under-clay	3 to 4	0	32	6
6. Drab to blue clayey shale....	25 to 30	0	62	6

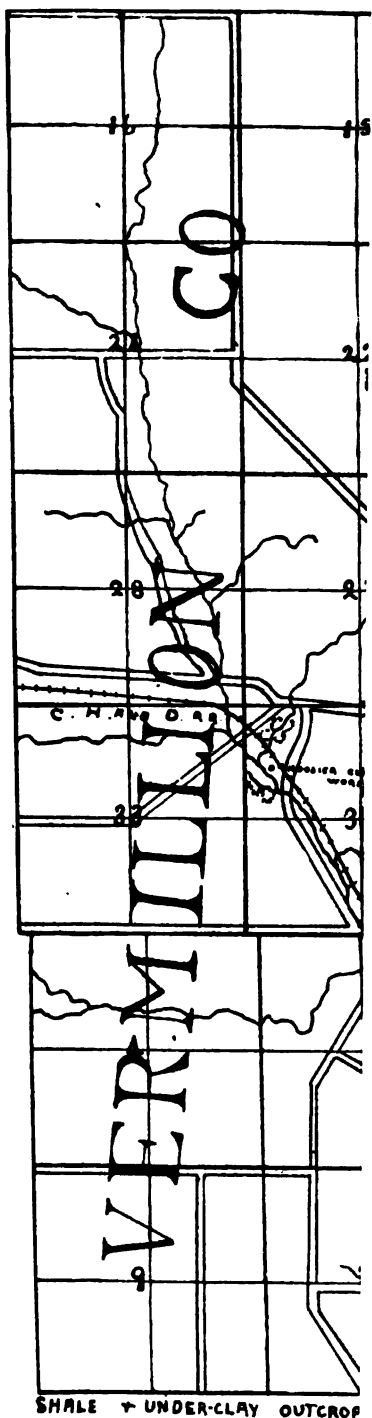


Fig. 5. Vicinity

1. The first part of the document discusses the importance of maintaining accurate records of all transactions. It emphasizes that proper record-keeping is essential for the transparency and accountability of the organization. This section also outlines the various methods used to collect and analyze data, ensuring that the information is reliable and up-to-date.

2. The second part of the document focuses on the implementation of the proposed changes. It details the steps involved in the transition process, from the initial planning phase to the final execution. This section also addresses the potential challenges that may arise during the implementation and provides strategies to overcome them.

3. The third part of the document discusses the long-term impact of the changes. It highlights the expected benefits, such as improved efficiency and cost savings, and provides a timeline for when these benefits are expected to be realized. This section also includes a discussion on the ongoing monitoring and evaluation of the changes to ensure they are meeting the intended goals.

4. The fourth part of the document provides a summary of the key findings and conclusions. It reiterates the importance of the changes and the need for continued commitment and support from all stakeholders. This section also includes a list of recommendations for future actions and a call to action for the organization to move forward with the changes.

7. Concretionary iron carbonate (two bands)		6	63	0
8. Black fissile shale.....	2 to 3	0	66	0
9. Coal VIb	1	0	67	0
10. Under-clay (white siliceous). 5 to 7		0	74	0
11. Blue and drab clayey shale.	42	0	116	0
12. Black sheety shale.....	2	0	118	0
13. Coal VIa	1	8	119	8
14. Under-clay	8	0	127	8

Of these, Nos. 3, 5, 6, 10, 11 and 14, aggregating from 84 to 89 feet of workable clays, and Nos. 4, 9 and 13, comprising 4 to 7 feet of fuel suitable for their burning, are found in the one place. Near the mouth of the ravine Mr. Burns, in 1872, erected a plant and began the making of fire brick from the clay No. 10. A switch from the C. & E. I. Railway runs to the plant, while the C., H. & D. Railway, one mile south, furnishes direct connection with all eastern and western points.

The gray sandy shale, No. 3, overlying the top vein of coal is, in places, cut out by the overlying sandstone, the latter resting directly upon the coal. In such places the coal is much thinner than where the shale forms its roof. This shale can be made into pressed front and ordinary brick and, mixed with some of the lower deposits, into vitrified products.

The coal (No. VII) has been mined at numerous places in the vicinity, and furnishes part of the fuel for the burning of the fire brick at the plant below. It is a very good semi-block coal, which burns into a white ash with no clinkers, but the vein is apt to be pockety, as in some test entries driven by the railway company it ran down to 8 inches in a distance of 70 yards.

Stratum No. 6 is a dark blue clayey shale or "soapstone" which weathers to a lighter drab in places. It burns to a close-textured body of a handsome dark red color. Near the lower part of this stratum of shale are the two bands of iron carbonate (No. 7 of the section), the upper being 4 inches thick and the lower 2 inches, the two being separated by a stratum of shale 14 inches in thickness. The pieces of ironstone are quadrangular and have the appearance of bricks laid regularly in place.

The upper half of shale No. 11, on the Burns & Hancock land, contains much more free silica than the lower, and in places, especially farther north, is replaced by a compact gray sandstone. The

lower half is the soft, unctuous, argillaceous material so well fitted for vitrified products. This stratum of shale is found exposed for a distance of 20 feet by the side and within 30 feet of the kilns of the Hillsdale Fire Brick Co., one-half mile farther south. Fifty or more carloads of it were shipped from there to Chicago and made into roofing tile. It brought 30 cents a ton on board the cars.

Analyses of the two shales, Nos. 6 and 11, were made by Dr. Lyons for the 1895 clay report, their chemical composition being found to be:

*Analyses of Shales Nos. 6 and 11, from the Burns & Hancock Land,
West Montezuma.*

	<i>No. 6.</i>	<i>No. 11.</i>
Silica (SiO_2)	46.07	56.32
Titanium oxide (TiO_2)	1.19	1.07
Alumina (Al_2O_3)	24.22	24.34
Water combined	9.76	6.33
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Clay base and sand.....	81.24	88.06
Ferric oxide (Fe_2O_3).....	9.65	5.60
Ferrous oxide (FeO)34	.24
Lime (CaO)19	.31
Magnesia (MgO)	1.31	.54
Potash (K_2O)	1.66	2.85
Soda (Na_2O)	2.76	2.34
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Fluxes	15.91	11.88
Carbon dioxide (Co_2).....	2.87
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Total	100.02	99.94

The analyses prove the chemical fitness of the clays for making sewer pipe, hollow brick and similar products, the percentage of fluxes being sufficient to bring about vitrification at the proper temperature. No. 11 is a purer and more refractory clay than No. 6, and will shrink less in burning. A mixture of the two would probably make better vitrified wares than either used alone.

The under-clay (No. 5) is a soft, dark plastic material containing *stigmæria* and other remains of plant fossils. It vitrifies to a dark brown, and one or two kilns of sewer pipe of good quality were made from it some years ago, as an experiment, by Mr. Burns. These were sold to the old L. D. & W., now the C., H.

& D. Railway, and are now in use along that line in the vicinity of Montezuma.

Under-clay No. 10 is nearly white and contains so large a percentage of silica that it resembles in appearance a sandstone. It is the most refractory under-clay that has been discovered in the State, and the fire brick and furnace linings made from it have been put to the most severe tests possible, and have everywhere given the best of satisfaction. Large numbers of the brick are sold annually to iron manufacturers as far west as Montana, and south to Georgia and Alabama. A kiln at the Burns and Hancock factory, the brick of the floors and walls of which were made of this clay, was torn down in July, 1904, after being in constant use for 32 years. A number of the brick were still so well preserved that they were used in constructing a new kiln on the site of the old. An analysis of this clay by Dr. Lyons shows the following percentage composition:

Analysis of Under-Clay No. 10, from Land of Burns & Hancock, West Montezuma.

Silica (SiO_2)	83.44
Titanium oxide (TiO_2).....	1.29
Alumina (Al_2O_3)	10.36
Water combined	3.15
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Clay base and sand.....	98.24
Ferric oxide (Fe_2O_3).....	.27
Ferrous oxide (FeO).....	.28
Lime (CaO)36
Magnesia (MgO)14
Potash (K_2O)03
Soda (Na_2O)71
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Fluxes	1.79
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Total	100.03

From this it will be seen that the clay is of high refractory grade, and moreover, very pure. It contains less fluxes than any plastic under-clay so far discovered in Ohio, and lacks but .02 per cent. of being as pure as the Mineral Point flint clay of that State, which is largely used in making high grade refractory materials, such as glass pots and kindred products. The only objection to the fire brick made from this clay is that for some purposes they are too friable, or easily crumbled. This is due to

the small amount of bonding material present, and can be readily overcome at any time by mixing with a small per cent. of a more plastic high grade under-clay, such as occurs at Mecca and many other points in the coal areas to the south. In Ohio, non-plastic flint clays constitute the body mixture of all the refractory wares made in the State, but it is necessary to use plastic under-clays with all of them to act as a bond material. The aim in selecting the plastic clays for a refractory mixture is to get as sandy a clay as can be had which will develop plasticity well. Under-clays, which have fluxing impurities ranging between two and six and a half per cent. will serve well for such bond. Mixed with such plastic under-clay the No. 10 clay from West Montezuma can be put to many uses for which it is now deemed unfit.

This stratum of clay underlies an area a mile or more wide, and extending from Hillsdale almost to Newport. It is said that it becomes more plastic in the southern part of this area and more refractory in the northern. It is at present worked by six companies whose plants are located along the C. & E. I. Railway, between the points mentioned. Four or five of these grind and ship large quantities of the under-clay, receiving therefor an average of \$1.15 a ton on board the cars. This is used for making mortar for laying and setting the parts of kilns, for rocks and adamant plaster, for lining ladles and making molds, and many other purposes.

Burns and Hancock have recently opened a new slope shaft into the side of the ravine about 35 feet above and 300 feet southwest of their plant. Through this shaft they mine the under-clay and the overlying coal VIb. Just above the opening of the drift there is a fine outcrop of shale No. 6, with its characteristic basal layers of concretionary ironstone nodules. The under-clay is here six feet thick, and rests on a sandstone which forms the upper part of stratum No. 11 of the section last given. All the under-clay used in their plant is now gotten from this new shaft, while that which is ground and shipped is secured from the old opening on the north side of the ravine. They pay 40 cents a ton for mining and delivering the clay at the dump, and two cents a bushel for mining the overlying coal—VIb.

Nos. 12, 13 and 14 of the above section are beneath the sur-

face level at the site of the plant of the Montezuma Fire Brick Company, and were secured from a record of a well boring.

Soon after the 1895 clay report was published, in which special mention was given to the clays of this portion of Vermillion County, Mr. D. N. Lanyon bought up nearly a section of the land comprising the bluffs north of West Montezuma, at an average price of \$10 an acre. In 1901 he sold to the Southern Fire Brick and Clay Company 133 acres on the north side of this tract for \$100 an acre. In 1903 Mr. Lanyon erected a clay grinding plant by the side of a switch of the C. & E. I. Railway in the northwest quarter of section 26 (16 north, 9 west). The shale, No. 11 of the West Montezuma section, is exposed to a thickness of over 50 feet near this switch. Above this shale and just west of his plant he has opened a slope shaft from which he mines under-clay No. 10, for grinding and shipment. In July, 1904, this shaft had been run back some 200 feet, and at this point the under-clay was, by actual measurement, 13 feet thick. The upper two-thirds was very similar to that used by Burns and Hancock, while the lower third was a little darker, finer grained, softer and more plastic.

North of the Lanyon land, in the southwest quarter of section 11 (16 N., 9 W.), Jackson Bros., of Newport, own a tract of 80 acres which contains a fine deposit of under-clay, No. 10 of the general Montezuma section. This clay outcrops 600 feet west of the C. & E. I. Railway and about 60 feet above the railway grade. A section from the surface to the bottom of the under-clay shows as follows:

Section on Land of Jackson Bros.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil and surface.....	0	8
2. Drab to blue clayey shale.....	25	0
3. Black sheety shale.....	2	0
4. Coal VIb	1	0
5. Under-clay No. 10.....	7	0

The under-clay is here very fine grained and more plastic than at the mines farther south. An analysis by Dr. R. E. Lyons, for this report, showed its composition to be:

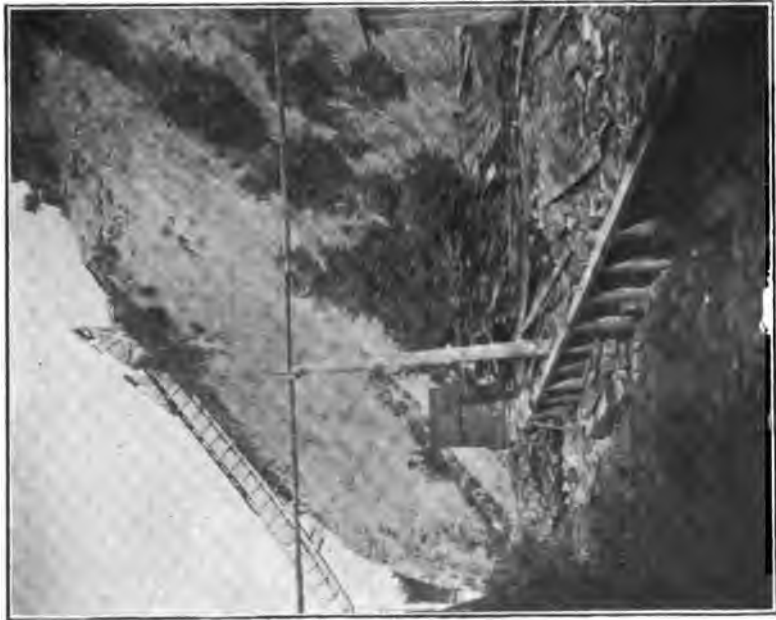
Analysis of Under-Clay from Land of Jackson Bros.

Silica (SiO_2) ..	64.05
Titanium oxide (TiO_2).....	1.10
Alumina (Al_2O_3)	20.55
Moisture	8.88
<hr/>	
Clay base and sand.....	94.58
Ferric oxide (Fe_2O_3).....	2.61
Ferrous oxide (FeO).....	1.42
Lime (CaO}) .....	.29
Magnesia (MgO}) .....	.58
Soda (Na_2O}) .....	.40
Potash (K_2O}) .....	.51
<hr/>	
Fluxes	5.81
<hr/>	
Total	100.39

The analysis shows a much higher percentage of alumina than the clay of Burns & Hancock, hence its greater plasticity. It can be used for high grade refractory wares, such as glass pots, tank and furnace blocks, etc. It will also serve well as a bond clay for non-plastic fire clays and kaolins. Fire brick made from it will be tougher and less liable to crumble than those from the same stratum farther south.

A level spot of four or five acres, between the railway and the clay outcrop, offers an excellent site for a factory. A switch can be easily constructed. The shale, No. 2, above the under-clay, can be utilized for many kinds of vitrified products.

The Southern Fire Brick and Clay Company erected, in 1902 and 1903, on their land in the southeast quarter of section 22 (16 north, 9 west), a \$130,000 factory. Their plant is about one and a half miles north of the Burns & Hancock factory on a tract of low land in a valley extending back from the face of the main Wabash River bluffs. To it a switch of the C. & E. I. Railway has been extended. Less than 50 feet south of their factory a bluff of shale, No. 11 of the West Montezuma section, rises 68 feet from the level of the plant to within six feet of the bottom of No. 10 under-clay. This intervening six feet is composed of light gray shaly sandstone, most of which can be ground up and mixed with the 68 feet of underlying shale. The latter is a soft, light blue, clayey material, which can be made into all kinds of vitrified products.



Shale Deposit 70 feet thick, by the side of the Plant of
the Southern Fire Brick & Clay Co., West
Montezuma, Vermillion County.



Outcrop of Under-clay No. 10, used by the Southern Fire
Brick & Clay Co.

Under-clay No. 10 is being worked by two or three drift entries. At the openings of these it is six feet eight inches in thickness, of a light gray color, quite hard and bearing, in places, traces or small fragments of plant remains. Just above it is the thin vein of coal, VIb, and over this 18 to 25 feet of the blue to drab clayey shale, No. 6, with its characteristic basal layers of concretionary iron bands and black sheety shale.

From under-clay No. 10 the Southern Fire Brick and Clay Company is making an excellent grade of fire brick which are sold under the name of "Mt. Silica Brick;" also cupola block and tile. It is the intention to, in time, use the thick beds of shale for different kinds of vitrified wares.

Between the Burns & Hancock factory and Hillsdale are the plants of two other companies which mine and grind the No. 10 clay. The northern one of these is known as the Wabash Valley Clay Works, erected in 1903. It is a small concern which mines from leased land about 90 tons of clay per week. According to the superintendent, it costs 40 cents per ton to get the clay to the plant and 15 cents for grinding and loading into cars, leaving a profit of 55 to 60 cents per ton.

The other plant, that of the Hillsdale Fire Brick Company, in the southwest quarter of section 35 (16 north, 9 west), began the making of fire brick and grinding of No. 10 clay in 1888 and carried on the business until 1903, when the plant was shut down, owing to the fact that the supply of clay controlled by the company was nearly exhausted. The plant is still standing, with the machinery intact. The ground clay was shipped for 15 years to the Chicago Steel Company and other large consumers, and gave the best of satisfaction. The stratum of clay in the mine ran 5 to 7 feet in thickness. Coal VIb, one foot thick, was left for a roof in the clay mine.

In the northwest of the northwest of section 34 (16 north, 9 west), coal VIb outcrops 15 to 18 feet above the bed of Raccoon Creek, and is overlain by 8 to 14 feet of dark blue shale with bands of iron, and underlain with clay No. 10.

On the southwest of the northwest quarter of section 34 (16 north, 9 west), one and a quarter miles west of Hillsdale, on the south side of the C., H. & D. Railway, Mr. J. S. Hollowell, of Montezuma, owns 40 acres, which is almost covered with excel-

lent deposits of shale and under-clay. A spur from the railway has been extended to the north side of the tract and a plant erected for the purpose of grinding clay for shipment. This plant is operated under the name of the Hoosier Clay Works, and is well fitted with modern machinery. A tramway connects the plant with the mouth of a slope shaft 450 feet to the south. In July, 1904, this had been opened back several hundred feet into a stratum of under-clay. In the room where mining was then going on the stratum of clay was 11 feet in thickness and appeared to be made up of three layers which merged one into another. The top layer, four feet in thickness, is dark gray in color and quite plastic when ground. The middle layer, four feet ten inches thick, is a very light gray, quite siliceous in appearance and less plastic. The bottom layer, two feet two inches thick, is intermediate between the two above it in color and plasticity, and lies directly on a bed of sandstone.

In a ravine on the south side of the 40 acre tract, a bed of soft drab to blue clayey shale, 18 to 24 feet in thickness, with very little cover, is exposed. It has near its bottom two bands of ironstone nodules and a band of black, sheety shale, below which is a vein of coal 16 inches in thickness, immediately overlying the under-clay mined on the other side of the hill. The character and relative stratigraphy of these deposits show that they correspond to Nos. 6 to 10, inclusive, of the West Montezuma section, the under-clay mined for shipment being of the same stratum as that used at the Burns & Hancock plant. It is ground and shipped to many points by Mr. Hollowell, being used extensively for saggars by the National Tile Company, at Anderson, and for the body of their wares by the U. S. Encaustic Tile Co., of Indianapolis. The former company use only the clay from the top stratum and pay \$2.00 per ton, f. o. b. the cars at the mine. The U. S. Encaustic people use an average of one ton a day. Coal III or IV, four feet or more in thickness, probably underlies this area at a depth of about 150 feet. With much of the necessary machinery, and a railway switch already in place, and with an abundance of high grade raw materials in sight, a large clay industry could be easily and cheaply started at this place, and would, without doubt, be a success from the beginning.

Township 15 North, Ranges 9 and 10 West.

The Coal Measure exposures in these congressional townships are scarce, as the greater part of their area in Vermillion County is taken up with the Helt and Grand prairies.

Three-fourths of a mile southwest of Hillsdale, in the southwest quarter of section 3 (15 north, 9 west), the bottom of shale No. 11, of the West Montezuma section, rests on four feet of fissile black shale beneath which is coal VIa, ten inches thick. The under-clay of this coal, eight feet thick, is a fine grained, light colored siliceous material which, when free from impurities, will make a good stoneware. A Mr. Yoke for some time made from it a patent "stone" fence post, and proved the clay to be refractory enough to stand up under the heat required for glazing. Immediately beneath this fire-clay coal VI occurs three and a half feet thick, and has been mined in a number of places southwest of Hillsdale.

In a ravine one-fourth of a mile east of the old clay works on the Yoke farm, the following section is exposed:

Section in Southeastern Corner of Section 3 (16 N., 9 W.)

	<i>Feet.</i>	<i>Inches.</i>
1. Yellow shale	20	0
2. Black shale	2	0
3. Coal VIa	1	8
4. Fire-clay	11	0
5. Coal VI	3	4
6. Shelly to massive sandstone.....	10	0

One mile south of Hillsdale, in the northwest quarter of section 11 (15 north, 9 west), the National Drain Tile Company purchased, in 1901, 80 acres of land lying on both sides of the C. & E. I. Railway. The tract on the west of the railway, consisting of 44 acres, is comprised mainly of upland, whose eastern border forms the bluffs of the Wabash, and embodies a part of the same clay deposits which are coming into use so rapidly in this region. Soon after the purchase of the land, the company invested \$50,000 in a modern drain tile factory, and fourteen round down draft kilns of the latest pattern, and began the burning of tile four inches to 30 inches in size. In the making of their daily output 90 cubic yards of shale are used. In July, 1904, this was being obtained from a pit 300 feet west of the factory, a section of which showed:

Section of Clay Pit at Hillsdale Plant of the National Drain Tile Company.

	<i>Feet.</i>	<i>Inches.</i>
1. Surface, yellow clay.....	4	0
2. Buff to drab clayey shale.....	16	0
3. Blue clayey shale.....	4	8
4. Black sheety shale.....	2	0
5. Coal VIa	0	10
6. Under-clay	7+	0

The lighter color of the upper shale, No. 2, is probably due only to leaching water from the overlying clay. The lower shale, however, seems more tough and plastic. Scattered nodules of kidney iron ore are rather plentiful and have to be thrown to one side by the workmen, who receive 15 cents a yard or 45 cents a car for the clay delivered at the plant. One hundred yards southwest, on the south side of a narrow ravine, the bluff is higher and a vein of under-clay nine feet thick is exposed above the shale stratum, here 25 feet thick. Over this under-clay is a 20-inch seam of coal, and above the latter 18 inches of black sheety shale. This upper coal vein is probably coal VIb, and the exposed under-clay is the No. 10 of the West Montezuma section. It is here a little darker and more plastic than in its northern exposure. For a time it was mixed with the shale for making the drain tile, but as it burns buff, the color of the tile was too light and not uniform, hence its use was abandoned. It can be made into hollow brick, conduits, flue linings, etc., but will not be found as suitable for fire brick as that north of Hillsdale.

Water for the tile factory is pumped from the Wabash River, 1,500 feet to the east, to a tank on the bluff, 125 feet above the river and 90 feet above the plant. Coal from Clinton, costing \$1.40 per ton laid down, is used as fuel. This is but one of many similar sites available for a large clay industry along the Wabash bluffs between Newport and Clinton. All four factors necessary to the success of such industry are here present, and the region is destined to become a great clay manufacturing center.

In the valley of Norton's Creek, in section 33 (15 north, 9 west), a gray sandy shale, 35 to 45 feet in thickness, overlies coal VIb. It outcrops in many places about two and a half miles northwest of Clinton, along a switch running from the C. & E. I. Railway to the mine of the Norton Creek Coal Company. It



Shale Pit at Hillsdale Plant of National Drain Tile Co.



Plant of National Drain Tile Co., one mile south of Hillsdale, Vermillion County.

also comes close to the surface at many places in the northeast quarter of section 5 (14 north, 9 west), and the south half of section 32 (15 north, 9 west). It contains more free silica than that worked nearer Clinton, and was for some time mixed with the blue, more plastic shale at the pit of the Clinton Paving Brick Company. Care must be taken, however, in mining it, as in some places the beds contain numerous rounded nodules of iron carbonate. These, when broken open, show a formation of concentric layers, surrounding a nucleus of some foreign body, about which is more or less calcite, or crystalline carbonate of lime and iron sulphide or pyrites. The latter impurity, when ground up with the shale in any quantity, is very harmful, causing the fluxing to take place at a temperature below that at which thorough vitrification occurs. If these concretions be carefully gleaned from the shale, the latter will be found in every way suitable for vitrified products. This shale lies from 10 to 12 feet below coal VII, five feet in thickness, which has been worked to some extent in its immediate vicinity. Separating the two are four feet of a good quality of under-clay and from four to six feet of sandstone, the latter lying on top of the shale. A switch being already in place, this is an excellent location for a factory for vitrified brick or sewer pipe.

Coal VIII probably underlies much of township 15 north, 10 west. It outcrops along Brouillet's Creek, in section 28, and is, or has been, worked at several places. At Sylvester Miller's bank, in the southeast of northwest of section 28, the coal is four feet thick, overlain by two feet of bone coal or black shale, and that in turn by four feet of clay shale. Below the coal is four feet of clay, and a well section is reported to show 86 feet of shales beneath the under-clay.

Township 14 North, Ranges 9 and 10 West.

These two congressional townships form the extreme southern portion of Vermillion County, a part of 14 north, 10 west, lapsing over into Illinois. Along Brouillet's Creek, in the western part of this area, occurs coal VIII, of the Ashley Survey, not found in Indiana north of Vermillion County. Immediately below this coal there is an under-clay, about four feet in average

thickness, which will be found of good quality for many clay products. This under-clay rests on a bed of flinty fossiliferous limestone, below which, and above coal VII, there is a bed of blue to gray clayey or sandy shale, ranging in thickness between 20 and 55 feet. Where coal VIII is absent, as in many places along the west bluffs of the Wabash between Clinton and Terre Haute, this shale, with or without its overlying limestone forms the surface, being extensively used for vitrified products in the vicinity of West Terre Haute. In a few localities it is too hard and siliceous to be used alone, but for the most part it is a soft, fine grained, unctuous material, suitable in the highest degree for manufacturing purposes.

Near the bottom of this shale deposit there is often a thin band of limestone, and below the clay shale a layer of bone coal and black sheety shale, the latter forming the roof of coal VII. Below coal VII, which is the principal vein worked in the vicinity of Clinton, there is usually three feet of under-clay and then a thick bed of sandy to clayey shale, which extends nearly down to the horizon of coal VIb. A general section of this area from above coal VIII to the bottom of the under-clay below coal VIb, would, therefore, run about as follows:

General Section in the Vicinity of Clinton.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil and clay.....	9	0
2. Shale or under-clay.....	4	6
3. Black shale or bone coal.....	2	0
4. Coal VIII	4	4
5. Blue gray under-clay.....	5	0
6. Limestone, gray, flinty, fossiliferous.....	2	8
7. Gray to blue sandy or clayey shale.....	53	0
8. Limestone, hard, flinty.....	1	0
9. Dark blue shale.....	5	8
10. Bone coal and black sheety shale.....	4	0
11. Coal VII	5	0
12. Under-clay	3	0
13. Drab to blue sandy to clayey shale.....	60	0
14. Black sheety bituminous shale.....	3	10
15. Coal VIb	1	8
16. Under-clay	5	0

One and a half miles northwest of Clinton, on the southeast quarter of section 9 (14 north, 9 west), the Clinton Paving Brick



Shale Pit of Clinton Paving Brick Co., one and a half miles northwest of Clinton, Vermillion County.

Company erected, in 1893, a large factory for the manufacture of vitrified brick from the shales of the vicinity. The principal deposit of shale used lies 100 yards south of their plant. In June, 1904, the following section was exposed, about 45 feet being in the vertical face and ten feet in a secondary and lower pit:

Section at Pit of Clinton Paving Brick Company.

	<i>Feet.</i>	<i>Inches.</i>
1. Surface soil and clay.....	3	0
2. Brownish red, sandy shale.....	6	0
3. Soft blue clayey shale.....	39	0
4. Black sheety shale.....	2	0
5. Hard black bituminous shale.....	1	10
6. Coal VIb	1	6

About two and a half acres have been worked out down to within eight feet of the coal since the factory was erected. The surface is stripped and then everything used down to the sheety shale above the coal. The two shales, Nos. 2 and 3 of the section, both form a portion of No. 13 of the general section above given, No. 2 being discolored by salts of iron leaching down from the overlying surface. While of good quality, this upper layer is rotten and shelly, breaking up readily into small quadrangular pieces. The main stratum of the shale, No. 3, is a soft, smooth and unctuous material, wholly free from grit in its lower portions. The upper 25 feet is more sandy, but when intimately mixed in equal proportions, as they are in the dry pans, the two layers form an ideal material for the making of paving brick. The company does not own the land, but pays \$100 a year for the shale used. About 140 tons are required each day to make 31,000 block. The quarrying of the shale is let by contract, the boss receiving 83 cents for getting out the material for each thousand brick and furnishing everything except the tracks and cars of tramway. Thirteen men, receiving an average daily wage of \$1.55, are worked in the pit.

At a distance of 12 feet from the top of the shale stratum No. 2, is the first of several bands of rectangular pieces of iron carbonate, about one and one-half inches thick. These bands occur at intervals of six inches and are seen almost entirely around the pit. Other scattered nodules of the same material are occasion-

ally found in the shale, but not in sufficient size and quantity to prevent their being ground and used. Running obliquely through the stratum of blue shale in several places are two or three narrow curved faults or fissures, in which a material much smoother and more unctuous occurs. This corresponds to the iron sediment found in similar faults at the shale pit of the Indiana Paving Brick Company, north of Brazil, Clay County.

When this shale pit was first opened the upper portion of the main stratum was not as sandy as at present, and the brick made of the material from this pit alone were apt to shrink too much in burning and to be too brittle, owing to the lack of silica. Mixed with a more siliceous material, the blue stratum was found to be capable of being made into a strong hard brick, with a very low power of absorption. In order to furnish the proper amount of silica, the company formerly used the yellow drift clay overlying the shale in another part of their yard, in the proportion of three-fourths of the shale to one-fourth of the clay. Later they hauled from a point on Norton's Creek the sandy shale already mentioned, which they mixed in equal proportions with the No. 3 of their pit. The hauling proving too expensive they, in 1895, hit upon a shale deposit one-fourth of a mile east of their works which, when mixed with the No. 3, gave good results. Finally, as their pit was opened farther back into the bluff, the upper portion of No. 3 became of such a character as to furnish all the necessary silica. The block now made are of an excellent quality. An analysis of an average sample of the materials used in 1895, which differ little, if any, from those now used, was made by Dr. Noyes, and the chemical composition found to be:

Analysis of Mixed Shales Used by the Clinton Paving Brick Company.

Silica (SiO_2)	61.46
Titanium oxide (TiO_2).....	1.20
Alumina (Al_2O_3)	16.54
Water combined	5.09
<hr/>	
Clay base and sand.....	84.29
Ferric oxide (Fe_2O_3).....	3.77
Ferrous oxide (FeO).....	3.71
Lime (CaO}) .....	.66
Magnesia (MgO)	1.81

Potash (K_2O)	3.28
Soda (Na_2O)	1.09
<hr/>	
Fluxes	14.32
Carbon dioxide (CO_2).....	1.45
<hr/>	
Total	100.06

This shows a very close approximation to the standard average composition of such clays, and proves the mixture well fitted for the purpose to which it is put.

Three-fourths of a mile southwest of Clinton, on the northeast quarter of section 21 (14 north, 9 west), coal VII, five feet six inches thick, is being worked by a shaft 45 feet deep, by the Indiana Bituminous Coal Company. The section of the shaft at the mine shows:

Section of Shaft at Mine of Indiana Bituminous Coal Company.

	<i>Feet.</i>	<i>Inches.</i>
1. Drift and surface.....	17	0
2. Blue shale	15	0
3. Limestone	0	6
4. Coal	1	6
5. Black bituminous sheety shale.....	5	0
6. Coal VII	5	6
7. Fire-clay	4	0
8. Sandstone	0	0

Nos. 2 and 7 of the section could be used in making many kinds of clay wares.

At mine No. 5 of the Indiana Fuel Company, two miles southwest of Clinton, in the southeast quarter of section 28 (14 north, 9 west), the sinking of the shaft disclosed the following section:

Section at No. 5 Mine of the Indiana Fuel Company.

	<i>Feet.</i>	<i>Inches.</i>
1. Surface and yellow clay.....	8	0
2. Shale, light gray sandy.....	48	0
3. Coal	1	0
4. Under-clay	4	0
5. Bastard flinty limestone.....	1	6
6. Dark blue shale.....	9	0
7. Black sheety shale.....	4	0
8. Coal VII	5	0
9. Under-clay	2	6

Nos. 2 to 9 of this section correspond to Nos. 7 to 12 of the general section. The shales Nos. 2 and 6 and the under-clays 4 and 9 could be worked with profit, the fuel being on the spot and transportation facilities at hand.

One mile farther southwest, in the northwest quarter of section 33 (14 north, 9 west), a switch from the C. & E. I. Railway has been run up a small tributary of Brouillet's Creek to the J. K. Dering mine. The shale stratum, No. 7 of the general section, is here said to be nearly 70 feet in thickness, and rises above the level of the switch near the shaft about 30 feet. The foundations of the buildings at the shaft rest directly on the shale. Coal VII, as mined, averages five feet in thickness. With the shale exposed, as it is, it can be very cheaply obtained. We have here, therefore, an excellent site for a large clay industry.

Surface clays are used in Vermillion County for brick and tile making only at Clinton and Rileysburg. At the former place an alluvial clay is used to a depth of seven feet without stripping, in the making of soft mud brick. At Rileysburg, after removing 12 inches of soil, the underlying clay is used for drain tile.

The above comprise the principal and more available deposits of commercial clays which came to my notice in Vermillion County. Many others doubtless exist. Those mentioned are sufficient in quantity, and in quality suitable to make for centuries many of the products which are now brought into Indiana from other States.

VIGO COUNTY.

Vigo County, in which the city of Terre Haute is situated, lies on the western border of Indiana, about midway between the north and south boundary lines of the State. It is almost quadrangular in shape, but as the Wabash River forms its southwestern border, the area of this portion is from one to five miles wider than the center. The county has an extent of 24 miles from north to south and a little less than 17 miles in average width; its area being about 402 square miles. It lies south of Vermillion and Parke counties, west of Clay County, north of Sullivan, and east of Clark and Edgar counties, Illinois.

The surface rocks of the county belong wholly to the Coal Measures Epoch of the Carboniferous Period, and are comprised

of alternating layers of sandstone, shales, coals and under-clays, with an occasional thin stratum of limestone. These surface rocks are everywhere, except along the larger streams, covered either by a thick layer of drift or, in the stream valleys, by alluvium.

"The Wabash River flows southwesterly through the county, so that about one-fifth of the area of the latter lies west and four-fifths east of the river. The immediate valley of the river is from four to five miles wide, occupying about one-fourth the area of the county. The river, at the ordinary stage of water, has an average width of about 600 feet. Low water at Terre Haute, near the middle of township 12 north, is about 445 feet above sea level. The river and its flood plain occupy the western third of the valley, the eastern portion being a broad terrace. The flood plain or first bottoms rise from 14 to 20 feet above low water in the river, while limited areas of 'second bottoms' rise from 10 to 15 feet above the flood plain. The terrace on the east rises from 50 to 75 feet above low water in the river, but toward the south, in Prairie Creek Township, it merges into the flood plain."*

The highlands on either side of the valley have an elevation of from 100 to 200 feet above the river, the bluffs in some cases being quite abrupt. These bluffs form the borders of the uplands, the latter being usually more or less broken by the erosion of small streams. These uplands extend to the confines of the county, and are underlain with coal. With the exception of the recent sedimentary clays of the river bottoms, all the commercial clays of the county are found in the uplands, or outcropping along the hillsides where the river terraces meet the uplands.

"The greater part of the county is drained by the Wabash and its tributaries. The principal streams from the west are Brouillet's Creek, Coal Creek, Sugar Creek (with several large branches), Clear Creek and Hawk Creek. These streams rise in Illinois and flow southeasterly into the river through valleys from one-quarter to a half mile wide and from 30 to 80 feet in depth. The streams from the east are Otter Creek, Lost Creek, Honey Creek, Prairie Creek, Turman's Creek and Busseron Creek. Portions of Pierson and Riley townships are drained to the southeast by Splunge Creek into Eel River. The

*Boovell, 31st Ann. Rep. Ind. Dep. Geol. and Nat. Res., 1896, p. 507.

valleys of the river and its tributaries seem to be the channels of an earlier drainage system that have been partly filled with sand and gravel, so that in many cases the beds of the present streams are from 25 to 100 feet above the rocky beds of the older channels. These smaller streams are, for much of the summer, "lost creeks," a fairly good stream among the hills disappearing in the sands and gravels of the main valley."*

In Vigo County the conditions are especially favorable for successful coal mining; for the growing of grain and market garden products, for stock raising and for many forms of manufacturing. The clay industries along the west bluffs of the Wabash have developed rapidly in the past five years, and there is little doubt but that the county will soon become one of the great clay industrial centers of Indiana.

Due mainly to the work of an energetic commercial club, Terre Haute in the past two years has grown very rapidly, and her population is now very near, if not beyond the 50,000 mark. Her transportation facilities can not be excelled for a city of that size, as no less than ten different railways either pass through or have their terminals within her limits. These are the St. Louis Division of the Big Four, and the main Division of the Vandalia, both of which pass east and west through the city and the full width of the county; the Peoria Division of the Vandalia, running northwest to Peoria, Illinois; the T., H. & L. Division of the Vandalia, northeast to Logansport and South Bend; two of the main divisions of the C. & E. I., running northwest and northeast; the E. & T. H., running south; the E. & I. and the Southern Indiana to the southeast, and the Chicago Division of the Southern Indiana to the northwest. Connecting all of these is a belt railway passing nearly around the city, while electric interurban lines extend east, north and west and add to the traffic facilities.

Township 13 North, Ranges 8, 9 and 10 West, and Part of 7 West.

With the exception of the Wabash terracé or second bottom, in the west half of 8 west and the east half of 9 west, this northern tier of townships in Vigo County is, in general, a rugged

*Seovell, Loc. cit., p. 506.

region, much broken and cut up by surface streams. Coal VI has its eastern outcrop near Coal Bluff; while coal VII in this area occurs only west of the Wabash River and in a small area about Atherton. In the area covered by coal VI, sandy shales or shaly sandstones predominate close to the surface, the layers of workable clayey shales being few.

One mile northeast of Coal Bluff, in the southeast quarter of section 5 (13 north, 7 west), a drilling near the Gladstone mine showed the following strata between the surface and the under-clays below coal IV:

Part of Section Near Gladstone Mine, Northeast of Coal Bluff.

	<i>Feet.</i>	<i>Inches.</i>
1. Coal Va	1	3
2. White shale	4	5
3. Blue shale	15	0
4. Sandstone	10	0
5. Gray shale	3	0
Place of coal V		
6. Under-clay	7	0
7. Shale, blue	25	0
8. Sandstone	7	3
9. Shale, gray	4	0
10. Coal IV	4	2
11. Under-clay	3	0
12. Shale, blue	10	7

Of the strata passed through, Nos. 2, 3, 6, 7, 11 and 12, aggregating 65 feet in vertical thickness can, if necessary, be used for clay products, and show a plentiful supply of clay working materials in this area. Railway facilities are excellent, as both the C. & E. I. and the Big Four have spurs penetrating this region.

One mile southeast of Coal Bluff, on the land of James Kessel, G. W. Eppert and Leonard Carter, in the south half of section 17 (13 N., 7 W.), a fair quality of potters' clay occurs in the valley of a small stream. The clay is exposed at several places in the bed of the stream, and test bores have shown it to be from six to 10 feet thick, and overlain with one to four feet of soil and gravel. The bottom of the stream valley is about 250 feet in width, and 25 feet below the level of the surrounding region; the clay occurring at the depth mentioned over five

to six acres in this bottom. It is very probably the partially exposed and weathered under-clay of coal VI, which is found seven feet four inches thick, at a depth of 28 feet below the top of the hills on either side of the valley. The clay is a very white, fine grained, plastic material. It has been tested at Gas City and Brazil potteries and found to make a good grade of stoneware, its only drawback being that it has a tendency to stick to the molds.

The strata accompanying coal VII occur in the vicinity of Atherton, sections 6 (13 north, 8 west), and 1 (13 north, 9 west), and it is very probable that the overlying blue shales will be found in quantity in these two sections, but no record of their occurrence is at hand.

On the west side of the Wabash a switch of the C. & E. I. Railway has recently been extended south from Clinton to Mine No. 6 of the Indiana Fuel Company, on the land of T. Collins, in the northwest quarter of section 16 (13 north, 9 west). The shaft of this mine is in the valley of a small stream, and on the north side of the switch where it turns from the river valley into that of the stream there is an exposure of shale 22 feet thick. This is a soft drab to blue clayey shale of excellent quality for the making of vitrified wares. An occasional nodule of kidney iron ore is visible in the outcrop. This shale forms the greater part of the surface above drainage over a large area in this vicinity, being exposed 35 feet thick, about 150 feet east of the tippie of No. 6 mine. In this shaft coal VII occurs at a depth of 106 feet, the greater part of which is shale.

The Chicago extension of the Southern Indiana Railway is, at this writing, being built up the Coal Creek Valley, through sections 20 and 19 (13 north, 9 west), and 24, 14 and 15 (13 north, 10 west), and when completed will make available for the first time fine beds of shale and veins of coal in the northwestern corner of Vigo County. The spur of the C. & E. I., above mentioned as running south from Clinton on the west side of the Wabash River, has been graded as far south as the Coal Creek Valley. Near the point where this grade strikes the valley, in the northwest quarter of section 28 (13 north, 9 west), occurs a fine outcrop of shale. This exposure is best seen on the north side of a roadway, which runs east and west on the north side of Coal



Shale Bluff on Little Vermillion River, five miles north
of Dena, Vermillion County.
(See p. 132.)



Shale Bluff by side of Spur of C. & E. I. Railway, Fayette
Township, Vigo County.

Creek valley. Here it rises 15 or more feet above the level of the roadway, and is a soft, gray to blue clayey material. At a point 20 feet higher on the hill and 200 yards back from the valley the shale is overlain with sandstone. If the C. & E. I. extension be completed this deposit of shale will be less than an eighth of a mile north of its junction with the Chicago Division of the Southern Indiana, this junction being on the south side of Coal Creek Valley at the point where the latter merges into the Wabash River Valley.

Farther north thick beds of the shale overlying coal VII outcrop at a number of localities. At Durkey's Ferry, in the northwest quarter of section 21 (13 N., 9 W.), it is 18 feet thick and contains many ironstone nodules, some of which, when split open, disclose very fine impressions of fossil plants.

A general section of the Coal Creek Valley from the junction of its forks in the northwest quarter of section 23 (13 north, 10 west), to its point of mergence with the Wabash River Valley, would show the strata to be about as follows:

Section Along the South Side of Coal Creek Valley.

	<i>Feet.</i>	<i>Inches.</i>
1. Surface and boulder clay.....	8	0
2. Brown sandy shale.....	1	3
3. Drab to blue clayey shale with scattered ironstone nodules	30	0
4. Dark gray fossiliferous limestone.....	2	6
5. Black sheery bituminous shale.....	1	2
6. Coal VIIa	1	0
7. Under-clay, fine drab	4	6
8. Shale, gray to blue, with one or two bands of ironstone near its base.....	53	0
9. Coal VIII	4	8
10. Under-clay	7	0
11. Solid buff to gray limestone	3	6
12. Gray sandy shale.....	6	0
13. Sandstone, massive buff to gray.....	9	0
14. Shale, drab to buff.....	16+	0

In the southeast corner of section 19, just west of the "Coal Creek Hill" on the gravel road; there are exposures of a fine clay shale in the ravines on the south side of the creek. Coal VIII has been stripped a half mile farther up the creek, and the shale outcrops mentioned are those of No. 8 of the general section,

above the level of that stripping. The exposures are at the base of the shale deposit, the upper portion being covered with weathered shale and other material, so that the exact thickness of the shale at this point could not be ascertained, but it is evidently more than 40 feet. This deposit is not over 200 yards from the new Chicago and Southern Indiana Railway, with a good terrace or second bottom between for a factory site. Coals VII and VI, both of workable thickness, can be mined from below the shale, so that the site is one well worth the attention of prospective clay manufacturers.

On the north side of the creek at this point the sandy shale and sandstone, Nos. 12 and 13 of the section, outcrop 15 feet above the bed of the stream, just west of the bridge.

On the land of G. W. Leek, in the southwest quarter of section 19 (13 north, 9 west), the bed of the creek is just above coal VIII, which has here been stripped in a number of places. Near this point shale No. 8, 30 to 40 feet thick, outcrops in bold bluffs on the south side of the creek. On the north side, along the grade of the railway, the shale is, in general, covered with drift and weathered material, two to six feet in thickness; the bed of shale itself running thinner, but averaging 18 to 25 feet.

The Coal Creek Coal Company owns in fee simple, or has under lease, about 1,800 acres of land along this valley, and controls the finest deposits of exposed shale. One of the most available of these is on the south side of Coal Creek, on the southeast quarter of section 23 (13 north, 10 west). At this point the base of shale No. 3 outcrops 15 feet above the level of the stream, with black shale and a thin layer of coal VIIIa, below it. In September, 1904, an old abandoned cornfield occupied 20 to 30 acres of the slope of the hill above the shale outcrop. In this in many places the shale came to within two or three inches of the surface, so that no stripping would be necessary. The bed of shale will here run 20 to 30 feet in thickness, and is of a soft, gritless, very plastic material, suitable in the highest degree for vitrified wares of many kinds. The grade of the railway is about 200 yards to the north, and coals VIII, VII and VI, all of workable thickness, occur beneath the shale deposit. A dam across the stream will conserve water enough for all purposes or, if necessity required, it could be secured from deep wells or piped from

the Wabash River. One-fourth mile below this, also on the south side of the creek, in the southwest quarter of section 24, shale No. 8 outcrops 30 feet thick, with a layer of ironstone boulders in its lower third.

On the B. Swafford land, in the east half of section 15 (13 north, 10 west), there is a bluff of shale 25 or more feet in vertical thickness, exposed along Coal Creek. The line of the Chicago Division of the Southern Indiana Railway passes within a quarter of a mile of this outcrop.

Just above the junction of the two forks of Coal Creek, in the northeast of the northwest of section 23, the Coal Creek Coal Company owns 80 acres. On it the old shaft of the Eddington and Vermillion mine passed through the following strata:

Section of Eddington and Vermillion Shaft.

	<i>Feet.</i>	<i>Inches.</i>
1. Shale, light colored, fine quality.....	5	0
2. Limestone, impure and shaley.....	0	6
3. Coal VIIa	0	8
4. Shale, of good quality.....	34	0
5. Limestone, clayey	8	0
6. Shale	34	0
7. Coal VIII	4	8

Outcrops of both shale and under-clay occur in numerous other places in the Coal Creek Valley, but the above are all of which I have especial record. There is little doubt but that in a few years this region will be found a close second to West Terre Haute in the clay manufacturing business.

Township 12 North, Ranges 8, 9 and 10 West.

East of the Wabash River there are but few beds of good available clay material in this area. While coal VII occurs over much of the region, it is too close to the surface to have much shale above it, and that between it and coal VI is, in general, too sandy for clay wares. At Seeleyville the section exposed in the shaft of the "Ray" mine of the Vigo County Coal Company, disclosed 41 feet of sandy shale above the worked seam of coal VI. This contained too high a percentage of silica and mica to be of value. The under-clay of the coal is but 18 inches thick. A lack of time prevented my visiting the mines farther north

along the I. & St. L. Railway, but from the records of bores furnished me by the Coal Bluff Mining Company, I should judge the conditions there to be about the same as at Seeleyville.

West of the Wabash River there occur, in the area under consideration, the best known shale deposits of Vigo County, and the only ones which, up to the present, have been developed to any extent. These deposits are found in the bluffs of the Wabash and occur, in the main, just above coal VII, which is the principal worked vein in the area. A connected section along Sugar Creek, made from notes by Dr. J. T. Scovell, and published in the 1898 Coal Report, p. 749, will serve to show the average sequence and thickness of the strata in the upland area west of the river:

General Connected Section Along Sugar Creek.

	<i>Feet.</i>	<i>Inches.</i>	<i>Feet.</i>	<i>Inches.</i>
1. Surface, soil, and clay.....	1	0	1	0
2. Subsoil yellow clay.....	4+	0	5	0
3. Boulder clay	10+	0	15	0
4. Shale	5+	0	20	0
5. Coal VIII	1	4	21	4
6. Fire-clay and shale.....	3	0	24	4
7. Limestone, crystalline fossiliferous	2	0	26	4
8. Shale, light colored to red.....	6 to 12	0	38	4
9. Limestone, impure, flinty.....	1	0	39	4
10. Sandstone, massive	11	0	50	4
11. Sandstone, merging into shale.	14	0	64	4
12. Shale, bluish with ironstones in upper part.....	28	6	92	10
13. Bone coal and sheety shale....	1	0	93	10
14. Coal VII	4	8	98	6
15. Fire-clay	10	0	108	6

As shown by the above section, coal VIII, stripped on Coal Creek, has been reduced in this area until it is not workable. Below it are commonly found the two beds of limestone from five to 12 feet apart, and below these sandstone and shale to coal VII. The following extracts from Mr. Scovell's descriptions of the strata between coals VIII and VII may be taken as a general description of this area and the strata mentioned in the above section:

"The fire-clay and shale (Nos. 4 and 6) on Coal Creek and

northward are from six to 10 feet in thickness. Toward the south the variation in thickness is through a wider range. In every place that I have been able to examine this material it has been a fine clay shale, free from grit. In a bluff on Coal Creek, on the southwest of the northwest of section 28—12—9, in the lower part of this shale, there is a thin layer of fine-grained, siliceous rock, about one foot in thickness. It is light brown in color and is traversed by tubes of varying size, that possibly may have been worm tubes. It seems to be of limited extent.

"The limestone No. 7, along Coal Creek and northward, is flinty and nodular, often brittle, and breaking with a conchoidal fracture. Toward the south this limestone becomes a hard, somewhat crystalline rock, from two to three feet thick. The shale No. 9, below this limestone, is from three to 12 feet thick, resting usually on limestone below. This is a fine clay shale, generally free from impurity of any kind, but sometimes it is seamed with limestone, sometimes it is reddish or bluish, sometimes white or gray.

"In Fayette township, where examined, it was of a light color. On section 23 (12 north, 10 west), and on the southwest quarter of section 11 (11 north, 10 west), it is light colored, but on the south half of section 25 (12 north, 10 west), and on the east half of section 15 (11 north, 10 west), and at other places it is highly colored, but always of a fine quality. Near the center of section 23 (12 north, 10 west), the two limestones outcrop in the bank of Sugar Creek, and are separated by 12 feet of this valuable shale. But about a quarter of a mile west the limestones outcrop again, with not more than three feet of shale between them, and this containing quantities of limestone, generally in boulders.

"The lower limestone, No. 9, varies greatly. In the southern part of the county it is seldom as thick and never of as good quality as the upper one, and is called by the miners 'bastard limestone.' As it forms a thin layer over the sandstone below, they sometimes fail to recognize it as a limestone.

"The sandstone below this limestone is sometimes massive and of uniform texture, forming a good quarry stone, as on the southwest quarter of section 28, northwest of 28, and the southwest quarter of 16 (13 north, 9 west), but towards the south it is

fragile and shaly. It merges into the sandy shale, No. 11, which sometimes has a peculiar wavy structure. These sandy shales merge into the fine clay shales, No. 12, below, so that it is difficult to say how much there is of either of the three strata below the limestone. Perhaps the following section on section 24 (12 north, 10 west), will be about an average. Sandstone, 12 feet; sandy shale, 10 feet; clay shale, 30 feet.”*

One-half mile northwest of West Terre Haute, and just north of the point where the Vandalia Railway strikes the upland, is a tract of fine shale covered land, to which special attention was called in the 1895 clay report. In 1901 the Vigo Clay Company purchased 143 acres of this tract in the northwest quarter of section 19 (12 north, 9 west), and on it, about 50 rods north of the railway, erected a large plant for the making of hollow brick, fireproofing and kindred vitrified products from the shale No. 12. At the point where opened, the shale was covered only by drift material, a section of the pit in June, 1904, showing as follows:

Section of Clay Pit of Vigo Clay Company.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil and gravel (stripped).....	1	8
2. Yellow clay and decomposed shale, stained by oxide of iron	7	0
3. Blue shale	18	0
4. Ironstone band	1	4
5. Gray shale containing numerous particles of pyr- ites of iron.....	13	0
6. Coal VII	5	6
7. Under-clay	8	0

Of the above, Nos. 2 and 3 were being mixed and used in the proportion in which they occur. The iron pyrites in the lower gray shale strata, No. 5, had caused the abandonment of that portion of the pit. A separate coal shaft led down to the coal mined for fuel. Wares made from the under-clay No. 7 alone were found too difficult to dry. Mixed with the shale, in the proportion of one part to two, it made a fine product, but as some difficulty had been experienced in getting it intimately mixed, and as the shale occurs in plentiful quantity, the under-clay was not, at the time, being utilized.

*The *Geology of Vigo County*, in 21st Ann. Rep. Ind. Dep. Geol. and Nat. Res., 1896, pp. 531-532.

The mining of the shale in the pit is let by contract at 12½ cents per car holding a cubic yard. About 100 cars are used daily, being elevated by steam power to the dump above the dry pan.

Water in abundance for this factory and the other three factories north is secured from the old Vandalia gravel pit, about a third of a mile to the east. The hollow brick and other wares made by the company are easily and cheaply burned, of excellent quality, and have a wide sale. The company has been very successful from the beginning, having been far behind in their orders for most of the time during the three years their factory has been in operation. Some trouble is experienced with shrinkage, as the raw material is very "fat" or plastic. The addition of a small percentage of silica or ground sandstone would, doubtless, be of benefit. Eight or nine men are employed in mining the coal for fuel. The coal contains quite a quantity of sulphur balls, which are separated, cleaned of attached coal and sold at \$3.00 per ton f. o. b. at the factory.*

Just north of the plant of the Vigo Clay Company is that of the C. M. Miller Mining and Manufacturing Company, erected in 1904 for the purpose of making ordinary brick. Their clays are, for the most part, purchased from the Vigo Clay Company, being alluvial or river bottom clays obtained from the low ground about a quarter of a mile east and hauled in wagons to the plant.

One-third of a mile farther north, on the southeast quarter of the northeast quarter of section 18 (12 north, 9 west), the National Drain Tile Company erected one of their four Indiana plants in 1902, and began the making of drain tile in February, 1903, from the No. 12 shale. The factory is on a narrow terrace or second bottom of the Wabash Valley on the east side of the St. Mary's road, and about 150 yards east of the east border of the upland. Several switches of the Vandalia run to each of the clay factories along this terrace, the Big Four just to the north, and much the nearer to two of them, having, for some unaccountable reason, failed to put in a spur. The pit of this company is just north of the plant, and shows three to six feet of brownish yellow decomposed shale, with 12 to 16 feet of blue

*Full descriptions of this and other clay manufactories northwest of West Terre Haute will be found in a later section.

shale beneath. This material is worked down to the black sheety shale, four to ten inches of which occur just above coal VII. The latter is not, as yet, mined, but a slope shaft will be put in as soon as the clay pit has been opened a little deeper. The mining of the shale is let by contract at 32 cents per car holding two cubic yards, delivered at the pan. Six men are worked in the pit, five of whom receive an average wage of \$1.75 per day. Forty carloads of shale are taken out each day, this quantity being sufficient to make a kiln of tile which is the daily output of the factory.

Mr. J. F. Morris, the superintendent of this plant, informed me that he had never seen a tile made from this shale deposit crack in drying. The extraordinary quality of the shale for making hollow products is proven by this minimum of loss in drying. He said that at the Summitville plant of the same company, where he formerly worked, the tile are made of drift or surface clay, and when five tile are put in the dry room, an average of but little more than three are taken out in fit condition for burning. The loss by cracking in burning at the Terre Haute plant is small, and it is not the fault of the clay, but of the burner. The tile made at this plant range in size from four to thirty inches, and are shipped to all parts of the Mississippi Valley. A twenty-carload order for Lawrence, Miss., was being loaded at the time of my visit. This plant and the one south of Hillsdale, which uses practically the same material, are the most successful of the four in operation by the company, the demand for the output being at all times in excess of the supply.

The Terre Haute Brick and Pipe Company, in 1893, purchased 100 acres of land two and a half miles northwest of Terre Haute, in the northeast quarter of section 18 (12 N., 9 W.), almost all of which is underlain with shale and coal. Just above the high water mark of the Wabash River, and a few hundred yards south of where the St. Louis Division of the Big Four Railway strikes the uplands, this company erected, in 1894, a modern plant for the making of paving brick, hollow brick and vitrified wares. At this point the shale overlying coal VII comes close to the surface, a section in the pit just west of the factory showing, in August, 1904, as follows:



Shale Pit of Vigo Clay Co., one-half mile northwest of
West Terre Haute, Vigo County.



Shale Pit of Terre Haute Brick & Pipe Co., one mile northwest
of West Terre Haute.

Section of Clay Pit of Terre Haute Brick and Pipe Company.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil and yellow clay.....	2	6
2. Decomposed brownish yellow shale.....	4	0
3. Blue clayey shale.....	14	0

About six inches of the top is removed by scrapers and the remainder mixed as it comes from the pit. The main body of blue shale is a soft, unctuous material, wholly free from grit, and containing fewer kidney iron ore concretions than in the pit of the Vigo Clay Company. In the pit it was seen to lie in laminae one and a half to four inches in thickness. About 140 cars, holding one and a fourth cubic yards, are used each day to make 40,000 paving brick. The shale is mined for 15 cents per car, but is hoisted by the company, who furnish cars, powder, etc.

The shaft through which the Terre Haute Brick and Pipe Company mine their coal is located in a ravine about one-third of a mile northwest of their brick plant, near the center of their tract of land. Coal VII is mined at a depth of 50 feet. A new air shaft was being completed in August, 1904, which showed:

Section of Air Shaft Near Mine of Terre Haute Brick and Pipe Company.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil and alluvial clay.....	2	8
2. Shale, light gray	25	0
3. Kidney iron ore or ironstone.....	1	4
4. Bluish gray clayey shale.....	22	0
5. Coal VII	4	10
6. Under-clay	10+	0

The upper ten feet of No. 2 shale contains more silica than the lower portion, but when mixed with the latter renders it of better quality for working. The under-clay below the coal is not now being utilized, but will make a good grade of hollow brick or sewer pipe. The coal is hauled to the brick plant in carts and dumped by the side of the kilns. A tramway will eventually be put in for hauling both it and the under-clay. In addition to the land owned in fee simple, the company has under lease the coal and clay on 200 acres to the north.

Just to the west of the land of the Terre Haute Brick and Pipe Company is a 93-acre tract, owned by Hon. Charles Whitcomb,

all of which is underlain by the thick bed of No. 12 shale above coal VII. The coal on the tract is being mined, but the shale has not, as yet, been used. It will be found suitable for all kinds of vitrified products and for drain tile, pressed front and ordinary brick.

The same shale will be found beneath the surface of the greater portions of sections 12, 13, 24 and 25 and the west halves of 6, 7, 18 and 19 (12 N., 9 W.).

On the John L. Walsh farm, northeast quarter of 7, the shale is covered to a depth of five or more feet with surface soil and hardpan. The upper 60 feet of a bore drilled 400 feet northwest of the Walsh line, on the estate of the Sisters of Providence, showed the presence of the following strata:

Partial Section of Bore on Land of Sisters of Providence, Near St. Mary's.

	<i>Feet.</i>	<i>Inches.</i>	<i>Feet.</i>	<i>Inches.</i>
1. Surface	2	0	2	0
2. Hardpan	15	0	17	0
3. Under-clay	11	0	28	0
4. Drab soapstone shale.....	3	0	31	0
5. Blue soapstone shale.....	11	0	42	0
6. Limestone	1	0	43	0
7. Sandy shale.....	7	0	50	0
8. Limestone	2	6	52	6
9. Soft gray shale.....	1	0	53	6
10. Blue sandstone	1	0	54	6
11. Blue shale	6	0	60	6

Along West Little Sugar Creek, on the north half of section 15, and in the west half of section 9 (12 N., 10 W.), there is a bluff nearly a mile and a half long, on the lands of M. G. Lee, P. J. Ryan and Joseph Hickling, which is, in the main, composed of an outcrop of shale of good quality. In some places the exposure is 20 feet or more thick. The necessary stripping is variable, averaging about seven feet, and is heavy at no point along the stream. The outcrops are underlain with two or three workable veins of coal, and can be reached by a spur of the Vandalia, a mile or so in length, which can be readily constructed up the valley of the creek.

"A deposit of fine clay on section 22 (12 N., 10 W.), is said to be suitable for encaustic tiling and high-grade pottery wares. A partial analysis of this clay by Dr. W. A. Noyes is as follows:

Silica	50.36
Alumina	15.08
Oxide of iron.....	4.45
Loss by ignition.....	13.98
	<hr/>
Undetermined substances	83.87
	<hr/>
Total	100.00

"Prof. Noyes says that the undetermined substances appear to consist largely of lime. The clay, he thinks, may be of value for earthenware and similar products."*

On the "old Casto" or Thorp farm, in the southeast quarter of section 23 (12 N., 10 W.) is an extensive outcrop of shale No. 8 of the general section. This is within one-third of a mile of the Vandalia Railway and by the side of Sugar Creek, in which is found a never-failing supply of water. A vein of coal five feet thick is found at a depth of 50 feet and another at 130 feet. The shale is exposed to a depth of 12 feet, beneath four feet of overlying soil and clay. It is a soft, light gray, unctuous material, wholly free from grit or pyrites, easily cut with a knife and very plastic when ground and moistened. Sample paving brick have been made from it, which were very tough and almost non-absorbent. The shale, according to analysis by Dr. Noyes, has the following composition:

Analysis of Shale from the Old "Casto" or "Thorp" Farm, Sugar Creek Township, Vigo County.

Silica (SiO_2)	61.05
Titanium oxide (TiO_2).....	1.20
Alumina (Al_2O_3)	21.46
Water combined	6.94
	<hr/>
Clay base and sand.....	90.65
Ferric oxide (Fe_2O_3).....	5.57
Ferrous oxide (FeO).....	.71
Lime (CaO}) .....	.25
Magnesia (Mg}) .....	.70
Potash (K_2O)	2.34
Soda (Na_2O}) .....	.30
	<hr/>
Fluxes	9.87
	<hr/>
Total	100.52

*Scovell, Geol. of Vigo Co., 1896, p. 571.

The analysis shows this to be a much purer and more refractory shale than the average, and it will therefore have a tendency to shrink in burning, which can be readily overcome by mixing with it some of the overlying surface clay or a shale containing more silica. This analysis may be taken as fairly representative of the average composition of the soft, gray, unctuous No. 8 shale found in the uplands west of the Wabash River.

On the Larrimer land, in the northwest quarter of section 25 (12 N., 10 W.), occurs another large outcrop of shale No. 8. It is in a ravine one-eighth of a mile northwest of the coal mines which are worked on the same land. This shale outcrops over quite an area, and can be secured by easy stripping. It is underlain with two or more veins of coal, and can be easily reached by a switch from the Vandalia, one mile distant.

Samples of this shale were made into bricks with a Boyd dry press machine, and also into paving brick for Dr. J. T. Scovell. The pressed front brick were of a rich dark reddish-brown color, uniform throughout; had a clear metallic ring, did not shrink much in burning, did not warp, and were tough, not chipping easily. Architect Floyd, of Terre Haute, said of them "that no finer brick were ever laid in Terre Haute, and that they were worth \$30.00 per thousand, as well as one dollar was worth another."

The paving bricks shrunk considerably in burning, but did not warp. They were hard and tough and absorbed but little moisture. One of them, tested for strength by Prof. M. A. Howe, at the Rose Polytechnic shops, gave the following results:

*"A brick from Vigo County shale.—Cross breaking test.—*Area of cross section 8.49 inches, supported on knife edges six inches apart; the force applied by knife edge midway between the supports, using the Riehle testing machine. The brick broke under a pressure of 6,040 pounds, showing a strength per square inch of 2,900 pounds. In the compression test the brick was on cast-iron supports, with pine bedding. Area, 6.27 inches. The specimen cracked at 88,000 pounds and failed at 95,500 pounds, showing a strength per square inch of 15,230 pounds. A brick made from the bottom land clay used by the Terre Haute Pressed Brick Company, when subjected to the same tests, showed a

cross breaking strength of 1,300 pounds per square inch and a compression strength of 11,940 pounds per square inch. Another, composed of one-third shale from section 25 and two-thirds bottom land clay, showed a cross-breaking strength of 1,700 pounds per square inch."*

On the land of G. A. Harris, southwest of the southeast quarter of section 25 (21 N., 10 W.), the following strata are to be seen in a ravine a short distance northwest of the barn:

Section on Land of G. A. Harris.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil and surface clay.....	2	0
2. Limestone, flinty, fossiliferous.....	3	0
3. Soft blue shale.....	7	4
4. Limestone in thin layers.....	1	0
5. Sandy shale	8	0
6. Soft blue shale.....	2+	0

No. 3, here exposed, is evidently No. 8 of the general section along Sugar Creek. Near the middle of the stratum is a band of reddish purple shale a foot or so thick, which weathers into small lenticular fragments. When ground and moistened it is very plastic and tough, and would make a good modeling clay. The limestone No. 2 has been quarried to some extent for macadam. No. 6 is exposed in several places 150 yards farther down the bed of the stream leading from the ravine. It is the No. 12 of the general section, and is doubtless of good, workable quality and thickness.

On the old Butz farm, now owned by the G. W. Harris estate, at the slope shaft of the West Terre Haute Coal Company, in the southwest of the northeast of section 25 (12 N., 10 W.), the following strata are exposed:

Section on G. W. Harris Estate.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil and surface clay.....	2	0
2. Buff to drab sandy shale.....	28	0
3. Soft blue clayey shale	22	0
4. Sheety shale and bone coal.....	0	10
5. Coal VII	5	2
6. Under-clay in sump.....	6	8

*Squovell, Geol. of Vigo Co., 21st Ann. Rep., p. 569.

Nos. 2, 3 and 6 of the section are all of them of good quality, capable of being made into many kinds of vitrified products. No. 2 by itself is best suited for ordinary or dry pressed brick. Mixed with No. 3, it will add to the quality for paving brick or sewer pipe. This exposure is two and three-quarter miles a little south of west of the court house at Terre Haute, and seven-eighths of a mile south of the Vandalia Railway. A spur to reach it would have to cross Sugar Creek, but otherwise the expense would not be above the average for such distance. The same strata will be found close to the surface over the 40 acres just west, viz., the southeast of the northwest of section 25. Coal VII, as here mined, is of excellent quality, being much freer from sulphur than at some of the mines farther north.

The above constitute all of the clay deposits visited west of the Wabash River. The three large factories already in operation have fully tested the shales and under-clays and have proven their fitness for making almost every kind of vitrified ware used in the State. Other tests have shown them highly suitable for terra cotta, pressed front brick and ordinary brick. The under-clays, when properly washed, will also make a good quality of stoneware. Coal VII, 5 feet thick, is within 50 to 80 feet of the surface, and is mined at a number of places; coal VI, 270 feet below the surface, is six feet thick, and mined at the Deep Vein shaft, near the plant of the National Drain Tile Company. Other veins of coal of workable thickness occur below this. Three railways pass through this area and another is graded to within its border. Water in abundance can be had for the pumping. With all these factors present, it is safe to predict that within ten years clay factories of large size will be in sight of one another on the west bluffs of the Wabash from below West Terre Haute northward to Clinton and beyond.

From the alluvial or sedimentary clays, found in the lowlands or flood plain of the Wabash River, ordinary soft mud brick are made by a number of factories in the city of Terre Haute.* These factories are located along the western border of the eastern river terrace, and the clays used are obtained 100 to 400 yards west and about 35 feet below the level of the yards. The

*See statistical table near end of paper.

clay has been deposited where found by the high waters of the annual overflows. Its thickness has never been determined, but it is known to be more than 20 feet. It is very fine in texture, and, for a river bottom clay, remarkably free from pebbles and coarser impurities. It shrinks but little in burning, and forms a strong and durable brick, which, on a large scale, can be made for a little less than \$3.00 per thousand, and usually bring \$6.50 delivered in the city, the average cost of delivery being about 55 cents per thousand. Some of these common soft mud brick, made from bottom land clay in the south part of Terre Haute, and burned hard, showed, in tests made at the Rose Polytechnic, a cross breaking strength of 570, 540, 890 and 920 pounds per square inch, and a compression strength of 1,410 and 2,010 pounds per square inch. A brick two-thirds shale and one-third bottom-land clay showed a cross breaking strength of 1,200 and a compression strength of 5,070 pounds per square inch.

For a time dry pressed-front brick were made from this river bottom clay. They were very hard and smooth, but the clay had a tendency to burn into different colors. This necessitated much labor in the assorting of the finished product. No less than thirteen different shades were gotten from each kiln. This was doubtless due, in part, to the non-uniformity of chemical composition, which such a clay must, of necessity, possess, but more largely to the variations of the burning and position in the kiln. Nevertheless, by careful assortment, the company was successful in getting a good percentage of first-class brick, and the "seconds" sold readily at fair prices for sidewalks and foundations. The clay, coming, as it did, from the river bottoms, was quite full of moisture, and an artificial dryer was erected. This did not prove a success, and the plant was finally changed into one for making ordinary brick.

At Middleport, Ohio, similar sedimentary clays from the lowlands of the Ohio River are used by two large factories for the making of vitrified brick. They present the cheapest form of clay which can be used for paving material, as they can be dug by steam shovel for a nominal cost, and the labor necessary to prepare them for use is almost nothing. On the other hand, the excessive plasticity of the material is against it, as it is difficult to prevent faults of structure in forming the brick.

The analysis of the Terre Haute clay (Noyes, chemist) is here given side by side with that of a similar sedimentary clay from the lowlands of the Ohio River, near Columbia, Ohio, and which, according to Orton, "was worked into vitrified wares of high grade."

Analyses of Alluvial Clays from Terre Haute, Ind., and Columbia, Ohio.

	<i>Terre Haute.</i>	<i>Columbia.</i>
Silica (SiO_2) (total).....	66.11	63.73
Alumina (Al_2O_3)	13.78	17.17
Water combined	6.34	4.90
<hr/>		
Clay base and sand.....	86.23	85.80
Ferric oxide (Fe_2O_3).....	5.35	5.85
Lime (CaO)	1.67	.58
Magnesia (MgO)	1.78	.97
Potash (K_2O)	2.11	2.33
Soda (Na_2O)	1.15	.67
<hr/>		
Fluxes	12.06	10.40

The physical tests above mentioned show that brick from the Wabash alluvial clay did not rank well as compared with those made of the shale west of the river. The method of preparation and burning the sample brick might have had much to do with the low results obtained, as that method was doubtless the same as for shale brick. The chemical analysis above given shows nothing present which would affect the vitrification of the clay under the proper burning.

Township 11 North, Ranges 8 and 9 West.

In this area occur the principal clay deposits of Vigo County, east of the Wabash River. Township 8 west corresponds to Riley, and 9 west to Honey Creek of the civil townships. The area is drained by Honey Creek, which flows a little south of west across the two townships, and receives numerous small tributaries from the north and south. Three railways, the E. & T. H., the E. & I. and S. I., cross the region and furnish the best of transportation facilities. Coal VII occurs over the northern half and southwestern corner of Riley, and the northeastern corner and southern half of Honey Creek, and the shales above

this coal form the most valuable clay resources of the two townships. In section 31, in the southwestern corner of Riley, this shale is 50 feet or more in thickness.

One mile northwest of Riley, on the land of the J. M. Sankey estate, northeast quarter of section 17 (11 N., 8 W.), the E. & I. Railway runs by the side of a large deposit of soft, gray, clayey shale. This is more than 20 feet thick, and lies above Coals VII and VIb, the latter at this point being five to six feet in thickness and mined less than one-fifth of a mile to the southeast. The shale has been exposed in numerous places along the grade of the railway and, on the hill to the west, has but about two feet of soil and yellow surface clay above it. It is also exposed in the ditches along the Terre Haute and Riley road just to the east, and underlies the greater part of the D. M. Wallace farm on the east side of that road, the Wallace house standing on an elevation of the shale.

This shale is very free from silica and other impurities, and can be made into all kinds of vitrified products, terra cotta and dry pressed brick. With a railway already in place and good coal beneath it, it offers a most excellent site for the location of a clay-working factory.

At the Fisk mine, on the southwest corner of the Wallace farm, coal VIb of fine quality, being free from sulphur and burning to a white ash, is mined at a depth of 50 feet. A section of the shaft of the mine shows:

Section of Shaft of Fisk Mine, One Mile Northwest of Riley.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil and surface clay.....	4	0
2. Blue gray clayey shale.....	8	0
3. Gray sandy shale.....	3	6
4. Coal VII	1	6
5. Under-clay	1	8
6. Coal VII	1	6
7. Under-clay	4	0
8. Black bituminous shale.....	1	8
9. Sandstone	3	0
10. Limestone	4	0
11. Black sheety shale.....	12	0
12. Coal VIb	5	0
13. Under-clay	10	0

Not over three acres of the coal have as yet been worked out by the present operators, who pay 8 cents per ton royalty. The shales 2 and 3 and the under-clays 5, 7 and 13, aggregating 27 feet, are all workable products, and should be used in connection with the coal. Coal VII, here represented by two veins, separated by 20 inches of under-clay, could be mined with profit if the intervening clay were utilized.

Two miles west of Riley, on the southwest quarter of 18 and the northwest quarter of 19 (11 N., 8 W.), and on the northeast quarter of section 24 (11 N., 9 W.), there are outcrops of the shale overlying coal VII on the lands of B. Franklin, Spencer & Hazelton and W. Fair. These exposures were made while grading the east-west road that passes between the quarter sections mentioned. They are 3 to 12 feet in thickness, with 1 to 7 feet of yellow surface clay above and bottom hidden. The shale is drab to buff in color, but will be found blue at greater depths. It will make all grades of vitrified wares and dry pressed and ordinary brick. The Southern Indiana Railway passes between the outcrops and within 350 feet of all of them, while one or more workable veins of coal will be found below them.

On the N. Jones farm, in the northwest of the northeast section 18 (11 N., 8 W.), a bore in search of coal passed through 52 feet of blue clayey shale (soapstone) in the first 71 feet drilled. Coal VIb, four feet in thickness, overlying seven feet of a good grade of under-clay, was found at a depth of 117 feet.

On the old "Tuller" farm, in the northwest quarter of section 13 (11 N., 9 W.), is a bluff of shale 30 feet in thickness. The point where found is only one-quarter of a mile east from the E. & I. and S. I. Railways and one-half mile from the E. & T. H. Railway. A valley along which a switch could be easily constructed leads to all three. The shale is of good quality and contains a higher percentage of free silica than at the Sankey deposit near Riley, but not too much. Coal has not been found here, but borings will undoubtedly show the presence of one or two workable veins below the shale. A dam across Little Honey Creek, on which the outcrops occur, would insure a plentiful supply of water.

Of this Tuller deposit Dr. Scovell wrote:* "Specimens taken

*Geol. of Vigo Co., 1896, p. 570.

so as to represent the average of the bluff, both sand and shale, were sent to H. S. Grimes, Portsmouth, Ohio, who had them made into 'Hallwood block' pavers. When he sent the brick to me Mr. Grimes wrote 'that there never was a better brick made.' They were of a rich brown color and apparently in every way a first-class brick. They were considerably lighter than the ordinary block and somewhat larger, as they did not shrink in burning."

On the O. S. Smith land, in the northeast quarter of section 36 (11 N., 9 W.) is an exposure of good shale 12 feet or more in thickness, above the creek. Coal VII occurs a few feet below it, and is mined on the J. W. Smith farm, just to the west. On South Honey Creek, in the northwest quarter of section 25 (11 N., 9 W.), occurs a fine outcrop of shale, and on the same creek, in the southwest quarter of section 24, within one-half mile of the E. & T. H. Railway, is another exposure.

The above constitute the principal visible deposits in Riley and Honey Creek townships. A number of them well merit development, as all the necessary factors for a successful clay manufactory are present.

Township 10 North, Ranges 8 and 9 West.

Coal VII, with its overlying shales, overlies the west half of 10 north, 8 west (Pierson Township) and the east half of 10 north, 9 west (Linton Township). The Southern Indiana Railway runs northeast and southwest diagonally across Pierson, and the E. & T. H. north and south through the eastern third of Linton.

On the northwest quarter of section 6 (10 N., 8 W.), Pierson Township, there is a fine cliff of shale, known as the "Paint Mine." It is distant a mile and a quarter west from the Southern Indiana and one and three-quarters miles east of the E. & T. H. Railways. For a number of years the shale was pulverized, barreled and shipped to different parts of the country to be used as a body for paints. The company worked under difficulties of various kinds, but no fault was ever found with the material it sent out. Coal VII is reported to lie 32 feet below the Paint bank, and to be 18 inches thick. As there is 15 to 20 feet of shale over the Paint bank, there is indicated a thickness of about 50 feet of a fine grade of shale.

On the north side of the road which runs by the "mine" the shale is exposed above the water in South Honey Creek to a thickness of 19 feet, with 3 to 9 feet of surface clay above it. Near the bottom of the exposure are two or three thin bands of ironstone concretions. At the worked opening on the south side of the road the cover of yellow clay is 10 to 13 feet and the shale $16\frac{1}{2}$ feet thick. At this point, in August, 1904, the shale had weathered into cubical blocks, two to five inches in size, with few or no iron nodules visible. It is of a light gray color, very fine-grained and uniform in composition, and forms one of the finest exposures seen anywhere in the State. Mr. W. P. Blair, of the Terre Haute Brick Company, tells me that he has burned pieces of the shale in his kilns, and that no better burning material can be found. Dr. Scovell says that "in this locality there are several ironstone bands in this shale, with many nodules of the same material. One owner of the quarry used to make hone stones from these clay ironstone layers that were of the finest quality. They were known as the 'Fera hone stones.' The shale from this locality makes good brick, but they are mottled gray in color. If the ironstone were crushed with the shale, the mass would doubtless make a brick of a good red color and great strength. The material would make a handsome stiff mud, repressed front brick."

The same stratum of shale outcrops in a number of places along South Honey Creek, north of the Paint Mine, forming the surface rock over the greater part of the southeastern quarter of section 31. It is also exposed in a bold bluff about a half mile south on the same stream, the quality there being fully as good as at the Paint Mine. Another good exposure occurs on the S. Hedges farm, in the southwest quarter of section 17 (10 N., 9 W.), where an outcrop of coal VIII is overlain by 20 feet of clay shale.

On the land of William Forbes, southwest quarter of section 28 (10 N., 8 W.), along a branch of Busseron Creek, is an exposure of a good quality of the shale, overlying coal VII. The point of outcrop is four miles northwest of Lewis and three-quarters of a mile north of a branch of the Southern Indiana Railway. The outcrop rises 8 to 10 feet above the stream and has a cover of four to six feet of soil and yellow surface clay. Just

Pl. X.



Exposure of Shale at "Old Paint Mine," Pierson
Township, Vigo County.

Section of Burr on Burr Hendrickson land:

1. Soil and surface clay.....
2. Drab to blue shale.....
3. Coal VII: no part.....

Section of Barron Barr Hendrickson Land,
surface clay.....
blue shale.....
poor up.....

- | | Feet. | Inches. |
|--------------------------------|-------|---------|
| 1. Soil and surface clay..... | 6 | 0 |
| 2. Drab to blue shale..... | 30 | 0 |
| 3. Coal VII: poor quality..... | 3 | 0 |

	Feet.	Inches.
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.....	30	0
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to the west, on the land of Theo. Walters, northeast of southeast of section 29, are several other exposures. One of these extends eight feet above the stream and is several hundred feet in length. The shale is drab to light bluish gray in color, free from grit and of fine quality for all vitrified wares, terra cotta and various kinds of brick.

Less than one-quarter of a mile to the south, on the land of Burr Hendrickson, in the southeast of the southeast of 29, a drill hole showed:

Section of Bore on Burr Hendrickson Land.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil and surface clay.....	6	0
2. Drab to blue shale.....	30	0
3. Coal VII; poor quality.....	3	0

The thickness of the shale in this bore indicates that it will be found over quite an area in this region. Away from the streams the cover of yellow clay will run four to 10 feet, a part of which can be mixed with the shale if the latter is ever worked. Coals VI, V and IV, of workable thickness, should be found below coal VII.

The deposits of Vigo County clays above mentioned are all valuable, and a factory located at any one of them will, under normal conditions, prove a paying investment. The city of Terre Haute will doubtless maintain in the future, as it has in the past, a steady, onward growth, and will use clay products for buildings and roadways to the value of many millions of dollars. With large deposits of the raw materials suitable in the highest degree for making such products, with the best of fuel for burning these materials into their proper shapes, and with ten railways stretching in all directions, ready at a moment's notice to carry the surplus to less favored cities, there is no reason why the clay industry should not soon take front rank among the varied manufacturing interests of the county.

CLAY COUNTY.

This county lies a little southwest of the center of the State, being separated from the Illinois line by Vigo and part of Sullivan Counties. It lies south of Parke, west of Owen and the south half of Putnam and north of Owen and Greene Counties. In

general shape it is long and narrow, having a length from north to south of 30 miles, and a width varying from 10 to 16 miles, its area being 360 square miles.

The Geological Epochs represented in the surface rocks of the county are three—the Huron Group of the Lower Carboniferous and the Mansfield Sandstone and the Coal Measures of the Carboniferous Period. The rocks of the Huron Group outcrop only along Eel River and its tributaries, in the eastern third of the center of the county. Here the streams have eroded through the overlying Mansfield Sandstone, which forms the surface above and on either side of the outcrops of the Huron rocks; the area covered by this sandstone being also limited to the eastern third of the center. The Coal Measure rocks cover the western two-thirds of the center of the county and extend clear across its northern and southern thirds.

In general Clay County is very level, especially the western half. Some broken country occurs along the eastern margin, especially along Croy's Creek and east of Eel River, in Washington Township. Some rough country is also found in the northern third, along the banks of the north and south forks of Otter Creek, which cut deeply into the general level. With these exceptions, the existing streams have either not channeled deeply or their banks present rather gentle slopes. Eel River and many of the streams running into it have broad bottoms, the Eel River bottom becoming as much as five miles wide before leaving the county. Near the southwestern corner, on Splunge Creek, is a large basin with very gentle slopes. A part of this basin is drainless, except by artificial means.

While the surface of the county can be thus described as generally level, drilling and mining have shown that, could the soft surface deposits of sand, clay and gravel, laid down by the glacier or since, be removed, the surface would be found completely cut up with valleys of the old pre-glacial streams and their narrow intervening ridges. Except where some of the larger existing streams have in part cut out the filling of their old channels, the present surface gives no clue to the irregularities of the old surface. As these old hidden valleys are often broad and up to 150 feet deep, they often cut out large strips of coal, and make almost valueless a piece of coal land that, judging only from the present

surface, would be supposed to be entirely underlain with coal and clay. This makes it necessary to make a large number of drillings in order to determine the amount of coal or clay under a given piece of land.

The north and south forks of Otter Creek, flowing into the Wabash River, drain the northwestern part of the county. The rest of the county is drained by Eel River, which empties into White River. Croy's Creek, Six-Mile Creek, Hog Creek, Birch Creek, Big Creek and White Oak Creek are the principal tributaries of Eel River.

Clay County, especially in its northern half, is well supplied with railroads. The St. Louis Division of the Big Four crosses the northern edge of the county, while the Terre Haute and Indianapolis (Vandalia) Railway, of the Pennsylvania System, crosses at the latitude of Brazil, and, with its Center Point and other branches, forms the chief outlet for the central portion. The Central Indiana (Midland) runs north from Brazil through Carbon. The Momence Division of the Chicago & Eastern Illinois runs northwest from Brazil, and, with several branches, serves as the outlet for Chicago and the north. In the southern part of the county is the Evansville & Indianapolis Railway, branching at Saline City to Brazil and Terre Haute, where connections are made in all directions. The final surveys of two other lines, viz., the Indianapolis Divisions of the Monon and the Southern Indiana, are now being made, and they will probably be completed in 1905. They will pass east and west through the southern half of the county, and will make easily available much coal and clay which has hitherto been of little value on account of a lack of transportation facilities.

Clay County has long been noted as the mining center of Indiana. Its beds of non-caking block coal are the most extensive found in the United States, and their development has added much to the wealth and prosperity of the county. The beds of bituminous coal underlying the western half of the county are also of great economic value, and their working gives employment to many hundreds of men.

Since 1890, however, another industry, based upon the clay resources of the county, has come to the front, and will soon outstrip even that of coal mining in importance. Brazil, the county

seat, has become, since that date, the leading clay manufacturing center of the State. Eleven large companies, each with an invested capital of \$40,000 to \$200,000, have been formed, and are to-day busily engaged in making from the under-clays and shales of the vicinity many different kinds of clay products. Previous to the date mentioned, the clays of Clay County had received little attention. Two potteries had used the under-clay of coal V for making stoneware, and Weaver Bros. had, for 21 years, made "stone" pumps from the under-clay beneath coal IV. Other than this no use whatever had been made of a resource which is destined to equal in value that of the seams of coal which it accompanies.

Township 13 North, Range 6 and Part of 7 West.

This area, comprising 60 square miles, lies along the northern edge of the county, and embraces the civil townships of Van Buren, Brazil and Dick Johnson. It is well traversed with railways, and, except the southeastern corner of 13 north, 6 west, is overlain with coals V, IV and III. Of these coal V is usually known as the rider vein, and coals IV and III as the "upper and lower block veins."

The main workable clays in the area are a bed of blue to gray shale overlying coal V, a bed of similar shale between coals V and IV, and the under-clays below coals V, IV and III. The shale above coal V is in places black, bituminous and sheety; in other places it acquires a thickness of 20 to 30 feet, in which case it is usually a drab or blue color, and has been found very suitable for the manufacture of clay products. At some points its middle portion is replaced by a shaly sandstone. The under-clay below V is, when weathered or properly ground and washed, a good stoneware or potters' clay, having been used for 40 years in potteries in the vicinity of Brazil.

The space between coals V and IV is very variable in thickness. In the Ashley shaft, just northeast of Brazil, it is over 35 feet. At the New Nickel Plate mine, a mile and a half farther northeast, it is only about four feet at one point, but will average about 20 feet. Its most prominent member is a massive sandstone from five to 15 feet thick. This sometimes lies directly on

coal IV; more often there is a stratum of dark blue workable shale between it and the coal.

Between coals IV and III the space is generally fairly constant, though varying over the field from 20 to 35 feet, with an average of about 30 feet. Its most characteristic member is the mixture of sandstone and shale known as "sand-slate" or "fake." This usually overlies shales, often reddish or brownish in color. Pure sandstone is seldom found in this space, though noted occasionally.

A section of the "old Carbon shaft" may be taken as showing the average sequence and thickness of the strata in the region about Carbon:

Section at Old Carbon Shaft.

	<i>Feet.</i>	<i>Inches.</i>	<i>Feet.</i>	<i>Inches.</i>
1. Clay and drift.....	12	0	12	0
2. Clay shale	3	0	15	0
3. Sandstone	5	0	20	0
4. Gray clay shale.....	7	0	27	0
5. Coal V	4	6	31	6
6. Under-clay	3	0	34	6
7. Clay shale	2	0	36	6
8. Gray shale	3	0	39	6
9. Sandstone	10	6	50	0
10. Dark gray clay shale.....	7	0	57	0
11. Coal IV	3	0	60	0
12. Under-clay	2	6	62	6
13. Sandstone	2	0	64	6
14. Sandstone and shale.....	10	6	75	0
15. Bluish shale	11	0	86	0
16. Coal III	4	0	90	0
17. Under-clay.				

Coal V occurs very near the surface in the vicinity of Carbon, and is probably limited to a very small area or to a few isolated pockets. Coal IV occurs from 50 to 60 feet below the level of the Big Four Railway at Carbon, and is largely worked out, but its underlying clay has never been used.

One-fourth mile northeast of Carbon, on the land of James A. Kerr, northwest quarter of section 5 (13 N., 6 W.), some good deposits of clay are exposed alongside a switch of the Big Four Railway. A section through these clays at the point mentioned shows:

Section on Kerr Land, Near Carbon.

	<i>Feet.</i>	<i>Inches.</i>
1. Yellow surface clay.....	6	9
2. Shale, blue gray, clayey.....	8	0
3. Coal IV	4	1
4. Light gray under-clay.....	6	4

These correspond to Nos. 1, 10, 11 and 12 of the general section, Nos. 2 to 9, embracing coal V and its accompanying strata, having been carried away by pre-glacial erosion. The yellow surface clay is grayish yellow in color, free from lime pebbles, and can be used for ordinary brick or for mixing with the shale, No. 2, for vitrified wares.

The shale overlying the coal weathers freely to a soft plastic clay, which has every appearance of being suitable for paving brick, sewer pipe, hollow brick and kindred products. Coal IV has been mined to some extent by slope shaft, and the underlying clay is therefore well exposed. It is a fine quality of light gray under-clay, suitable for stoneware, hollow brick, terra cotta, conduits and numberless other wares, such as are made in quantity at Brazil from the same stratum. In thickness the layer equals that found at Brazil, while in quality it is as good, if not better. Some trouble might be experienced in securing a lasting supply of water on this tract, but aside from that, it is a most promising site for a prospective clay manufactory.

On the land of John A. Wells, southwest of Carbon one-half mile, southwest of southeast of section 6 (13 N., 6 W.), coal IV has been stripped over an area of an acre or two. A section at the pit, or place of stripping, showed:

Section on Land of John A. Wells.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil	1	6
2. Yellow clay	5	0
3. Blue clay and sand, "joint clay".....	4	0
4. Blue gray shale.....	4	4
5. Coal IV	4	1
6. Under-clay	6	2

The yellow clay, No. 2, is as fine a quality of drift clay as occurs in central Indiana. It is very fine grained, free from impurities, and will make either a good dry pressed or a stiff mud facing brick. It will also be found suitable for encaustic tile and terra cotta.

The blue shale, No. 4, is a dark blue, very plastic material, which will be found suitable for many kinds of vitrified products. Its quality for some wares may be improved by mixing with the No. 2 clay in the proportions of two to one or three to one, as burned by itself it will probably shrink to some extent on account of its "fatness."

The under-clay, No. 6, is somewhat darker than that at Kerr's bank, but will serve for making all kinds of wares made from the same stratum of clay at Brazil. Samples of the three clays were made into brick by the Anderson Foundry & Machine Works, which company, in reporting on the results, said: "We have in our experience struck a great many different clays from yards, but never have we found three different samples from the same place that make as nice brick as the clay you sent us. The brick burn hard and have a ring which shows them to be of first-class quality."

This deposit is about one-third of a mile distant from both the Central Indiana and the Big Four Railways, and can be easily reached by a spur from either. The same clays occur over the greater part of the 125 acres owned by Mr. Wells, but the cover, on an average, will run four to six feet thicker.

On the south side of the Big Four Railway, two miles west of Carbon, in the southwest quarter section 1 (13 N., 7 W.), is the mine and clay factory of Benjamin Simpson. A section of the shaft, as given by Mr. Simpson, is as follows:

Section of Shaft at the Mine of the Simpson Fire Brick Company.

	<i>Fect.</i>	<i>Inches.</i>
1. Soil and surface clay.....	2	0
2. Yellow surface clay.....	4	0
3. Gray to yellow, shaly sandstone.....	17	0
4. Coal IV	3	10
5. Under-clay	6	8
6. Blue to gray shale.....	28	0
7. Coal III	3	2
8. Under-clay merging into sandstone.....	7	0

The No. 2 yellow surface clay is of good quality, and was shipped to the terra cotta and encaustic tile works at Indianapolis for a number of years, it being used at the tile works as the body clay for red tile. The under-clay, No. 8, is a white, very siliceous

material, three or four feet of which is mined and burned into fire brick, which have given good satisfaction wherever used. Some of the under-clay is occasionally shipped with the brick, and brings \$1.75 per ton, f. o. b. the cars at the mine.

The under-clay, No. 5, is softer and more plastic than No. 8, being of the same general nature as that from the same stratum at Carbon and elsewhere in the area. Neither it nor the blue shale, No. 6, have been put to use. While the raw materials and fuel are here present in sufficient quantity and quality to justify a large output of clay products, the business seems not to be carried on in the most successful manner, the plant being idle for several months each year.

On the north fork of Otter Creek, in the northern tier of sections of township 13 N., R. 7 W., are numerous outcrops of a blue clayey shale, in every way suitable for vitrified products. At the shaft No. 8 of the Brazil Block Coal Company (northeast quarter of section 3) it is exposed to a depth of ten feet by the side of the railway switch running past the mine. Both seams of block coal are mined at this place. The upper one, No. IV, is overlain with 14 feet of blue clayey shale and underlain with three and a half feet of under-clay, both suitable for manufacturing purposes. The under-clay of the lower vein of coal contains too much sulphur to be of any value. Having the three essentials, raw material, fuel and transportation, present, this is a most inviting site for a paving brick or sewer pipe plant.

Near the Glen No. 1 mine of the Coal Bluff Mining Company, on a spur of the C. & E. I. Railway, southeast quarter of section 4 (13 N., 7 W.), are several strata of under-clays, which, taken together, form a variety and quantity of different burning materials such as are seldom found on one piece of property. The point mentioned is a mile and a half east of Coal Bluff and the same distance west of Perth, a station on the Big Four Railway. A connected section of a hill and bore at the base of the hill, as furnished me by H. W. Jenkins, superintendent of the mine, shows the presence of the following:

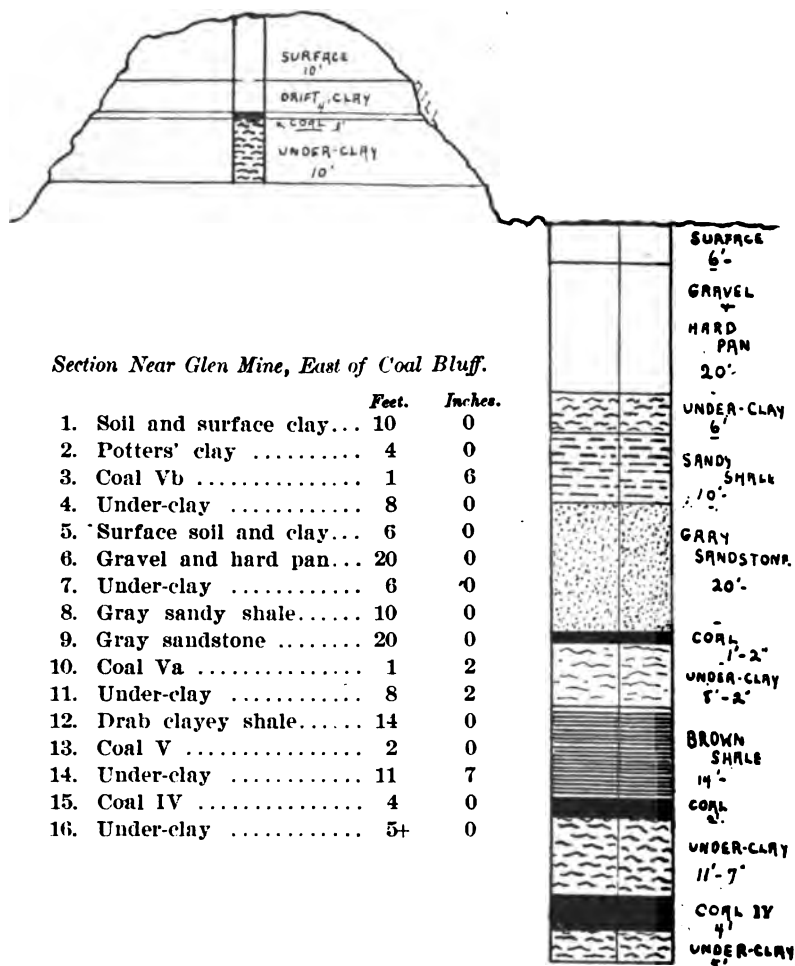


Fig. 7. Section near Glen Mine, east of Coal Bluff.

Nos. 1 and 4 of the section occur in the hill and 5 to 16 in the drill hole at its base. Samples of Nos. 2, 14 and 16 of the section were sent in by Mr. Jenkins. Potters' clay No. 2 is a very light gray, gritless, plastic material, which seems in every way suited for stoneware, flower pots, etc. It outcrops in several places around the hill, containing 25 or 30 acres, and the cover above it varies from four to ten feet in thickness. Under-clay No. 14 is the same vein worked in part at the Ayer-McCarel clay works, and wholly by the McRoy clay works of Brazil. It is a

light gray, plastic clay, which can be burned into all kinds of hollow vitrified products. This clay alone fills all the interval over 80 or 90 acres, between the rider vein of coal No. V and the upper block vein No. IV. Since it forms the roof of the latter, coal IV can not be mined unless the clay can be utilized, as the latter falls too readily.

The under-clay No. 16 is the characteristic dark gray unctuous material found below coal IV all over Clay County. It has been burned for years at several of the clay factories in Brazil, and its fitness for hollow vitrified products abundantly proven. With a four-foot vein of block coal between these two beds of under-clay, and with a railway switch already in place, no better site for a large clay industry occurs in Clay County.

At the Gart No. 5 shaft, in section 17 (13 N., 6 W.), northeast of Cardonia, coal III, three feet four inches thick, is mined. Above the coal is seven feet eight inches of blue shale of good quality, while below the coal the rock varies, in places being fire-clay, in others sandstone, showing the rootlets of the coal plants, and probably suitable for the uses to which gannister is usually put.

South of Otter Creek, in the immediate vicinity of Brazil, are some of the best-known shale and under-clay deposits in the State. As already mentioned, they are being utilized by eleven large factories, six of which have been built since 1895. The oldest of these is that of the Weaver Clay & Coal Co., established in 1872. The plant of this company is located on a switch of the Vandalia Railway, near the northeastern limits of the city of Brazil, in the northwest corner of section 32 (13 N., 6 W.). At this point the company owns six acres of land, the clay and coal used being secured from a leased 80-acre tract in the southeast quarter of section 30, one-half mile to the north. A royalty of 10 cents per ton is paid for the coal and 3 cents per ton for the under-clay. A tramway has been built between the plant and the clay deposit, both clay and fuel being hauled by mule power. At the mine coal IV, three feet six inches thick, is mined from a slope shaft. Twelve men are worked at the mine in securing fuel and clay, the contractor receiving 55 cents per ton for the clay and \$1.12 for the coal delivered at the plant. The under-clay is seven feet thick, but only the upper four feet are used, the lower

portion containing too high a percentage of small kidney iron ore nodules.

According to D. W. Weaver, who has been in the clay working business for 32 years, it takes, on an average, two and a half feet of block coal to furnish fuel sufficient to burn four feet of under-clay into hollow brick.

In 1903 a well 486 feet in depth was sunk on the south side of the Weaver company's boiler room. At this depth, in a limestone, a saline-sulphuretted water was found, an analysis of which, made by Dr. Blanchard, chemist of De Pauw University, showed the presence of the following constituents:

Analysis of Water from the Deep Well at the Plant of Weaver Clay and Coal Company, Brazil, Ind.—Bases and Acid Radicals.

	<i>Grs. per U. S. Gallon.</i>
Calcium (Ca)	539.11
Sodium (Na)	769.26
Potassium (K)	19.37
Magnesium (Mg)	610.76
Aluminum (Al.)	43.50
Chlorine (Cl.)	775.26
Sulphate (SO ₄)	597.30
Carbonate (CO ₃)	679.21
Silica (SiO ₂)	7.50
Iron (Fe)	1.50
Total	4,042.77

These bases and acid radicals may be considered as combined, as follows:

	<i>Grs. per U. S. Gallon.</i>
Calcium sulphate (CaSO ₄).....	191.70
Sodium sulphate (Na ₂ SO ₄).....	53.28
Potassium sulphate (K ₂ SO ₄).....	23.48
Magnesium sulphate (MgSO ₄).....	619.83
Aluminum sulphate (Al ₂ (SO ₄) ₃).....	77.28
Calcium carbonate (CaCO ₃).....	709.43
Sodium carbonate (Na ₂ CO ₃).....	19.08
Potassium carbonate (K ₂ CO ₃).....	10.71
Magnesium carbonate (MgCO ₃).....	671.48
Calcium chloride (CaCl ₂).....	124.78
Sodium chloride (NaCl).....	1,337.18
Magnesium chloride (MgCl ₂).....	195.54
Sulphuric acid (H ₂ SO ₄).....	7.50
Ferrous oxide (FeO).....	1.50
Total	4,042.77

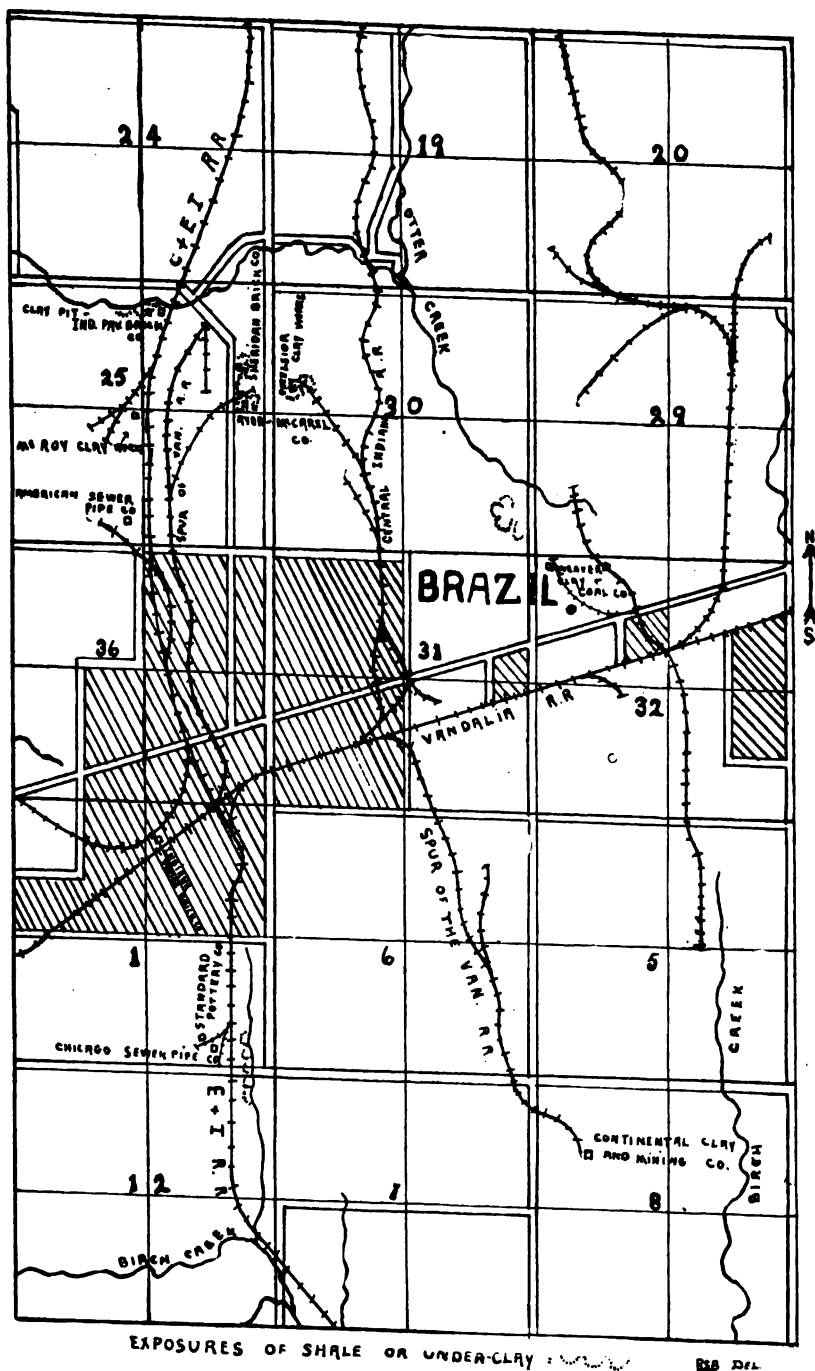


Fig. 8. Map of Brazil and vicinity, showing the location of clay factories and clay and shale deposits.



Shale Pit at Excelsior Clay Works, one and three-quarters miles northeast of Brazil, Clay County.



Shale Pit at Sheridan Brick Works, one and a half miles north of Brazil.

Gases.

	<i>Cu. In.</i>
Hydrogen sulphide (H ₂ S).....	4.941
Carbon dioxide (CO ₂).....	5.103

Judging by the taste and odor, there is much more salt (sodium chloride) and hydrogen sulphide gas present than in the water from a well of approximately the same depth at the plant of Ayer & McCarel, one and a half miles north of Brazil. Used in plentiful quantity, the water will be found beneficial for many kinds of stomach trouble, rheumatism, etc. At the Weaver plant it is used for pugging the clays, and it is claimed that the wares so pugged are much less liable to crack in drying than when pugged with ordinary surface water. It contains too much salt and sulphur for use in boilers.

On a switch of the Central Indiana Railway, one and three-fourths miles northeast of Brazil, in the northwest quarter of section 30 (13 N., 6 W.), is the plant of the Excelsior Clay Works, erected during the summer of 1895. The company owns 56½ acres of land, and mine their coal from a slope shaft and clay from a pit in a ravine 100 yards southwest of the plant. A section of the clay pit in August, 1904, showed:

Section of Clay Pit at Excelsior Clay Works, Brazil, Ind.

	<i>Feet.</i>	<i>Inches.</i>
1. Surface soil and yellow clay.....	4	0
2. Hard pan	5	6
3. Blue clayey shale.....	21	0
4. Black sheety shale.....	3	6
5. Gray to buff sandstone.....	3	0
6. Coal IV	3	8
7. Under-clay	6	0

The yellow clay, shale and under-clay are all used at the factory, being hauled up a rather steep incline by steam power. From 25 to 30 tons of the coal are mined daily, all of which is used at the plant. The hard pan, No. 2, has to be hauled away in carts and dumped. The shale is a dark blue, fine-grained material, wholly free from grit, which, when ground and moistened, becomes very plastic. It burns into a high-grade dark brown hollow block or paving brick. The under-clay burns to a buff or creamy white color, or, when glazed with salt, to a lemon yellow. It is used mainly for light-colored hollow block, but fire brick

made from it are used for the crowns, linings and floors of the down-draft kilns used by the company in burning all wares, the arches alone of the kilns being built of St. Louis fire brick. A mixture of the shale and under-clay burns to a stone gray hue.

Southwest of the Excelsior Clay Works, one-third of a mile, in the northeast quarter of section 25 (13 N., 7 W.), is the clay-working factory of the Ayer-McCarel Company. It was erected in 1902 and equipped with all the modern machinery and devices of an up-to-date plant.* The company owns 53 acres of land surrounding the plant, to which a switch of the Vandalia Railway has been built. Only under-clays are used at their plant, about 135 tons being mined each day from a pit and slope shaft, whose openings are in a small valley about 100 yards north of the plant. A section of the pit and underlying strata, as given by Mr. McCarel, is as follows:

Section in Clay Pit and Mine of the Ayer-McCarel Clay Company.

	<i>Fest.</i>	<i>Inches.</i>
1. Soil and surface clay.....	2	0
2. Shale, drab to blue clayey.....	25	0
3. Coal V	0	8
4. Under-clay	18	0
5. Black sheety shale.....	5	6
6. Under-clay	10	6

Coal IV, usually found above the lower under-clay, is lacking. The black sheety shale, No. 5, is in part or wholly replaced by sandstone in mines to the east. Of the strata given, only Nos. 4 and 6 are at present used, though the shale is of excellent quality, and will, in time, be utilized. Sixteen men are employed in the mine at scale wages for coal mining, and make an average of about \$2.42 per day.

The upper clay, No. 4, is lighter in color, harder, coarser, contains more silica, and is more refractory than the lower, the latter being the typical dark gray, fine-grained, plastic under-clay found beneath coal IV. About one-third of No. 4 is mixed with two-thirds of No. 6 in making the wares at the factory. Block coal mined on a separate tract belonging to the company is used as fuel. The water used for all purposes at the plant comes from

*For a further description of the clay industries about Brazil see the later section—"The Clay Industries of Indiana."



Office of Ayer-McCarel Company, made of hollow building block.



Mouth of clay mine of Ayer-McCarel Company.



Inside the clay mine of Ayer-McCarel Company.

a well 613 feet in depth. It has a temperature of 57° F., and a distinct taste and odor of hydrogen sulphide, but the amount of mineral matter present is so small that no compounds are necessary to remove scale from the boiler tubes. It is an excellent drinking water, and is used at many of the residences and at the larger hotels in the city.

Less than a quarter of a mile northwest of the Ayer-McCarel plant is the plant and clay pit of the Sheridan Brick Works,* established in 1898, for making ordinary soft mud building brick from shale and surface clay. The plant is located on a switch of the C. & E. I. Railway, over which a nominal switching charge of \$1.50 per car is made to other roads, the same as at all clay plants about Brazil. A well 603 feet in depth furnishes the same kind of water as is used at the Ayer-McCarel plant. Coal from the Brazil district, both block and bituminous, to the amount of 80 tons per day, are used at the plant. Sand for the moulds is obtained from Centreton, Morgan County.

At the clay pit, 150 yards east of the factory, the following section is exposed:

Section at Clay Pit of Sheridan Brick Works. (See Pl. XI.)

	<i>Feet.</i>	<i>Inches.</i>
1. Yellow clay	10	0
2. Drab to blue clayey shale.....	22	0
3. Coal V	0	3
4. Under-clay	6	0
5. Shale, blue	11	0

In some parts of the pit a gray limestone three to four feet in thickness occurs between the yellow clay and shale. This has to be removed, but otherwise everything except the coal is used, being scooped up by a steam shovel and loaded directly into cars holding three cubic yards each. Eighty of these carloads are used in making the daily output of 75,000 brick. Of the 22 acres owned by the company but about three and a half have been worked over in six years.

Two miles north of Brazil and one quarter of a mile northwest of the Sheridan Brick Works, on the south side of Otter Creek, near the bridge of the C. & E. I. Railway, is the upper pit of the

*For description of plant, see section IV.

Indiana Paving Brick Company. Since 1891 this company has used a stratum of blue shale 20 to 30 feet thick, which, at this point, lies directly over coal V, 10 to 20 inches thick.

The shale is gotten by blasting near the base of the worked ledge, when large quantities of it, sometimes 20 tons, come tumbling down. It is overlain with three feet of shelly sandstone, which must be separated and thrown aside. All the rest, including four feet of yellow surface clay, is loaded onto cars on a nearby railway switch and hauled to the factory in the western suburbs of Brazil. In the exposed ledge the shale is seen to be in laminae or layers from one-half to two inches thick. Some narrow perpendicular clefts or faults were noticed down which water, impregnated with oxide of iron, had passed, the water in time evaporating and leaving the mineral in thin sheets in the crevices.

One-half mile south of this pit, on the west side of the C. & E. I. Railway, near the center of section 25 (13 N., 7 W.), is the extensive plant of the McRoy Clay Works, located on the former site of the plant of the old Brazil Brick & Pipe Co. It is the most extensive clay manufactory in the Brazil district, and makes a specialty of electric conduits and hollow building block. The plant has been almost entirely rebuilt since 1900, when the old plant and 160 acres of land were purchased from the B. B. & P. Co. The raw material used at this plant is the under-clay below coal V or the rider vein. In August, 1904, this was being mined from beneath a leased 30-acre tract east of the railway, a royalty of 2½ cents per ton being paid for the clay. No coal of consequence is taken from the mine, but the clay runs up to 11 feet in thickness in some of the rooms, and 165 to 180 tons are used each day. Block coal is used as a fuel, and the water used at the plant is pumped from the city reservoir to a cistern at the works.

One mile northwest of Brazil, in the southwest quarter of section 25 (13 N., 7 W.), is the Brazil factory of the American Sewer Pipe Company, formerly belonging to the Monarch Sewer Pipe Company. This company manufactures sewer pipe, flue linings, wall coping, etc., from the under-clay of coal IV and from an overlying shale. The shaft of their coal and clay mine is but a few yards from their main building. A section to the bottom of the vein of clay used discloses the presence of the following strata:

Section at Shaft of American Sewer Pipe Company.

	<i>Feet.</i>	<i>Inches.</i>	<i>Feet.</i>	<i>Inches.</i>
1. Soil and yellow clay.....	12	0	12	0
2. Boulder clay, blue.....	7	0	19	0
3. Gray clayey shale.....	33	0	52	0
4. Coal V	2	3	54	3
5. Under-clay (potters' clay)	3	2	57	5
6. Blue clayey shale.....	19	0	76	5
7. Shale, dark bituminous, fossiliferous	1	6	77	11
8. Coal IV	3	6	81	5
9. Under-clay	5	4	86	9

The block coal, No. 8, is first mined and then the under-clay is taken up. The latter is light gray in color, free from sulphur or other impurities, hard when first mined, but weathers after a few weeks of exposure into a fine-grained plastic mass. Scattered through it are fragmentary fossil remains of the leaves and rootlets of the coal forming plants of the old Carboniferous marshes. It makes a strong and durable sewer pipe, which, with a salt glaze, becomes a light reddish brown on the outer surface. Shale No. 6 is the high-grade laminated clay found in many places between coals V and IV. A mixture of two-thirds of it with one-third of the under-clay burns to a handsome dark brown color, and makes a sewer pipe of great strength. Some of the wares, such as flue linings and chimney tops, are made of the under-clay alone, but most of the sewer pipe is made from a mixture of the shale and under-clay in the proportions mentioned. Shale No. 3 is also a good product for many wares, especially if mixed with either of the above.

The men in charge of this factory are practical clay workers of long experience in other states. They state that the block coal found in the vicinity of Brazil cannot be excelled for burning clay products. It contains less sulphur than any other fuel, and, as a consequence, a better glaze is secured on the surface of all wares.

All clay and shale used are raised through the shaft by the same power that runs the machinery of the plant, and then dumped from a tramway leading from the tippie to near the dry pans. A well 550 feet in depth was being completed in August, 1904, to furnish water. The company owns 134 acres surrounding the plant, the latter being the only Indiana representative of 36 simi-

lar factories located in Ohio, Michigan, Pennsylvania and West Virginia.

In the western suburbs of Brazil, just north of the Vandalia Railway, is located the oldest and best-known paving brick plant in Indiana, that of the Indiana Paving Brick Company. This company began making vitrified brick of the Coal Measure shales in 1891, and at the present time have an output of ten millions of such brick a year. Their raw material was, for a long time, mainly secured from their "upper clay pit," already mentioned as located near the Otter Creek bridge of the C. & E. I. Railway. At present they are using but three carloads, or 42 cubic yards daily from that pit and are securing the remainder, about 100 cubic yards, from a pit recently opened just to the northwest of their plant. A section at this pit, in July, 1904, showed:

Section at "Lower Clay Pit" of Indiana Paving Brick and Block Company.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil and yellow clay.....	9	0
2. Decomposed shale and yellow drift clay mixed...	5	0
3. Blue clayey shale.....	26	0
4. Coal V	2	8
5. Under-clay	5	0

Of these strata, Nos. 1 to 3, from "the grass roots" down, are used for the vitrified brick. The shale, No. 3, is a dark blue, exceedingly fine grained material, free from any impurity except a layer of iron carbonate concretions, three inches thick, about three feet below the top of the shale stratum. The shale weighs about 2,650 pounds to the cubic yard. Eight men are worked in the clay pit, the company paying eight cents per carload for mining the shale. Each car holds three-quarters of a cubic yard, and 130 carloads are used daily. The company owns 15 acres of land just west of the factory, all of which is underlain with shale, and have under lease four acres additional on which the present pit is located.

A new well, 657½ feet in depth, has just been completed to furnish water. A record of the bore as furnished by the company is as follows:

Record of Deep Well on Yard of Indiana Paving Brick and Block Company.

	<i>Feet.</i>	<i>Inches.</i>
1. Yellow clay	33	0
2. Shale	27	0
3. Coal	1	0
4. Under-clay	3	0
5. Shale	34	0
6. Under-clay	5	0
7. Shale	53	0
8. Black shale	42	0
9. Sandstone	101	0
10. White lime rock.....	71	0
11. Bedford rock (limestone).....	133	0
12. Blue rock	54	6

A partial analysis of the water, made in the laboratory of the Pennsylvania Railway Co., at Altoona, Pa., showed it to contain:

Partial Analysis of Water from Deep Well of Indiana Paving Brick and Block Company.

	<i>Grains Per Gallon.</i>
Total solid residue.....	9,030
Probable scale making material.....	1,776
Chlorine	40.50

The solid matter consists of salt, carbonates and sulphates of lime and magnesia and free bicarbonate of soda. It is a satisfactory water for boilers.

In sections 26 to 28 and 33 to 35 (13 N., 7 W.), northwest and west of Brazil, but little mining has been done, and but few outcrops of shale are visible. It is very probable that over much of this area the stratum of shale used by the Indiana Paving Brick and Block Company occurs. It will, however, have a heavy cover and will in most places have to be mined if it is ever utilized. A drilling near the waterworks in section 35, is reported to have shown the following section:

Drilling Near Water Works, West of Brazil.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil and yellow clay.....	23	0
2. Brown clay, probably decomposed shale.....	8	6
3. Blue to gray clayey shale.....	16	0
4. Coal V	0	8
5. Under-clay	2	6
6. White sandstone	8	6
7. Coal IV	3	2

8. Under-clay	5	0
9. Blue shale	4	0
10. Under-clay	5	6
11. Blue shale	2	8

This section shows the presence of a plentiful supply of clay working materials, beneath a heavy cover of drift.

Township 12 North, Ranges 6 and 7 West.

This area of 72 square miles embraces the civil townships of Jackson and Posey, the whole of the former and the eastern third of the latter being overlain with coals IV and III, with their accompanying shales and under-clays. Over the western two-thirds of Posey, coals V and VI occur often with a layer of workable shale above VI. Coal VII also covers the southwestern portion of the same township. That portion of this area immediately about Brazil will be first considered.

On the Brazil Branch of the E. & I. Railway, one mile southwest of Brazil, in the southeast quarter of section 1 (12 N., 7 W.), is located the plant of the Chicago Sewer Pipe Company. This company began in 1893 to make sewer pipe from the blue clayey shale overlying the No. V vein of coal and find it in every way suitable for their purpose. At their pit, situated 150 feet south of their plant, the following section is exposed:

Section at Clay Pit of Chicago Sewer Pipe Company.

	<i>Feet.</i>	<i>Inches.</i>
1. Surface soil and clay (stripped).....	1	6
2. Reddish yellow drift clay.....	8	0
3. Decomposed shale and reddish clay mixed.....	5	0
4. Drab to blue clayey shale.....	10	0
5. Coal V	0	4
6. Under-clay	5	6

In the making of sewer pipe and wall coping, a mixture of two parts of the shales, 3 and 4, with one part of the yellow drift clay, No. 2, is used. The company owns 16 acres, and in 12 years have used the clays down to No. 5 of the section only over about one and a half acres. As their superintendent aptly puts it, "We make and sell only a hole with a shell around it, and the larger the hole the higher the price we receive for it." The



Clay Pit and Plant of Chicago Sewer Pipe Co., one mile southwest of Brazil, Clay County.

amount of clay used in the making of hollow goods like sewer pipe is, proportional to the value of the output, much less than in making vitrified brick.

The drift clay, No. 2 of the section, is rather coarse grained, but is very plastic and free from pebbles of lime. The shale is of the same nature as that used at the plant of the Indiana Paving Block Company. By itself it burns to a dark cherry red; mixed with the surface clay in the proportions mentioned, to a brighter red. Glazed with salt, the sewer pipe becomes dark chestnut brown in color.

The members of the Chicago Sewer Pipe Company investigated the clays of Iowa, Illinois and Indiana before locating their plant at Brazil, and finally chose the present site as the one where clays of a superior quality for making sewer pipe could be secured at a minimum cost, and where fuel and transportation facilities were of the best.

Four hundred feet northwest of the plant of the Chicago Sewer Pipe Company is that of the Standard Pottery Company, which is the largest stoneware factory in the State, their daily output being 5,000 gallons for ten months in the year. The clay used is the under-clay of coal IV, and is gotten from the mine of the Pyrah Coal and Clay Company, two and a half miles south of the pottery; and from the W. B. Stone mine, one mile south of Pyrah's. Only the clay from the upper 22 inches of the stratum is used, and costs \$1.00 per ton on board cars at the mine. It is the soft, dark gray, plastic under-clay with traces of fossil plant remains, found beneath the upper vein of block coal over the northern half of Clay County. When properly ground and washed, it becomes a light gray in color, and burns into an excellent grade of stoneware.

On the Hoosierville Branch of the Vandalia Railway, two and a half miles southeast of Brazil, on the northwest quarter of section 8 (12 N., 6 W.), is the new clay-working industry of the Continental Clay and Mining Company. It was erected in 1903, and in April, 1904, began the making of hollow building block and kindred products. The clay used is an under-clay mined from a shaft, a section of which shows:

Section of Shaft of Continental Clay and Mining Company.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil and drift clay.....	11	0
2. Sandstone	15	0
3. Sandy shale	13	0
4. Blue clayey shale.....	7	0
5. Coal IV.....	3	5
6. Under-clay	5	3
7. Gray shale	4	10
8. Coal	0	11
9. Under-clay	5	6

The under-clay, No. 6, is alone used at present, but in time all of the strata, from 4 to 9, inclusive, will be utilized. The under-clay from below coal IV, now used, possesses the same qualities as at the other different plants about Brazil, and makes a hollow building block which does not crack in drying, and which possesses great strength and durability when properly burned. The company owns in fee simple twelve and a quarter acres of land on which the plant is located, and have under lease the coal and clay on a 280 acre adjacent tract, paying a royalty of two and a half cents per ton for clay and ten cents per ton for the block coal. Water in abundance and of excellent quality for both steam and pugging purposes is secured from a five and five-eighth inch well, 485 feet in depth.

Over the greater part of Jackson Township (12 N., 6 W.), coal IV occurs, averaging about four feet in thickness. In many places it is too close to the surface to work. In other places it has been worked out. It usually overlies a good stratum of under-clay, four to five feet in thickness, which could be very profitably used in connection with the coal. As already shown, this clay will make the best of vitrified hollow ware and stoneware.

At the Crawford No. 3 mine, one and a half miles northeast of Asherville, coal IV is absent, and a reddish clayey shale, 16 feet in thickness, occurs in the shaft just below the surface drift. This shale could be utilized for clay wares if necessity required. The under-clay beneath the worked vein, coal III, averages but about four inches in thickness.

In the vicinity of Hoosierville, in sections 18 and 19, coal IV occurs, 20 to 50 feet below the surface, with four to eight feet

of under-clay below it. This clay from the shaft of the Pyrah Coal and Clay Co., southwest quarter of northwest quarter of section 19, is, as already noted, used for stoneware by the Standard Pottery Company.

The Brazil Branch of the E. & I. Railway runs through the land of the Pyrah Company, and a section of their shaft shows as follows:

Section at Shaft of Pyrah Coal and Clay Company.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil and surface clay.....	23	0
2. Drab to blue clayey shale.....	24	0
3. Coal IV	3	9
4. Under-clay	8	0

The under-clay, No. 4, is the soft dark gray, gritless plastic under-clay found everywhere beneath coal IV in this region. It has been used from this mine for the making of encaustic tile, pottery, stoneware and electrical supplies, and has everywhere given good satisfaction. It brings \$1.00 f. o. b. the cars at the mine, the output in 1904 being distributed as follows: National Tile Co., Anderson, 301 tons; Wallace Machine and Foundry Co., Lafayette, 37½ tons; Uhl Pottery Co., Evansville, 40¾ tons; Standard Pottery Co., Brazil, 2,230 tons; total, 2,609 tons.

At the shaft of the Columbia No. 4 mine, near the center of section 21, coal V occurs at 85 feet, coal IV, 105 feet deep, and coal III 20 feet lower. The roof of coal IV is a blue clayey shale; this shale in the air shaft filling all the 20 feet of intervening spaces between coals V and IV. It would make vitrified wares of good quality, and if utilized for such purpose, would allow the mining of coal V, two feet eight inches thick.

On the land of Fred. Stearley, in the northeast quarter of section 27, there is an outcropping of gray, clayey shale along a branch of McIntyre's Creek. This outcrop shows a ten-foot face and is 200 feet or more in length. It is but a few hundred yards east of the Centre Point Division of the Vandalia Railway.*

In Posey Township (12 N., 7 W.), coal VI is the most important coal mined. It occurs only in the western two-thirds of the township and is, in part of its area, overlain by coals VIa and

*For location, see map of vicinity of Centre Point, p. 201.

VII. Between these two coals there is often a layer of blue, clayey workable shale, 12 to 20 feet in thickness. On the Alfred West farm, one mile west of Staunton, this shale was 20 feet thick, and overlain with sandstone. At the San Pedro mine in section 9, one mile northwest of Staunton, it is 12 feet thick and occurs immediately below the drift.

Just above coal VI there often occurs a soft gray clay shale resembling under-clay. At the Fortner mine, near the center of section 10, coal VI is overlain with nine feet of this material, the greater part of which could be readily and cheaply removed, and made into a good grade of vitrified ware.

South of Cloverland, three-fourths of a mile, in the bed of a creek on the farm of John Williams, is an exposure of blue clayey shale four and a half feet thick. Beneath this, coal VIa, two and a half feet in thickness, has been worked by stripping. At one point where the coal has been eroded some fine examples of "cone in cone" were obtained from the underlying fire-clay. These appeared as small cone-shaped masses of the fire-clay set one within another. They had the appearance of small concretionary or pressure structures, and were probably caused by the slipping of certain of the hardened fire-clay layers.

On the land of Henry Stedman, one and one-half miles west of Staunton, coal VI is mined, the vein in several places averaging seven feet in thickness. A drift boulder clay rests directly upon the coal, with no shale or slate intervening. Much of the coal may have been eroded by the glacier before this deposit of clay was made. "Hard pan," where the term is correctly used, applies to the second layer of drift or boulder clay, which is often separated from the first layer by a stratum of sand or gravel. It is usually an impervious stratum of hard, dark gray to blue clay mixed with small pebbles, and constitutes the most common water bearing horizon throughout the drift covered area of Indiana. The pebbles and other impurities mixed with it render it wholly unfit for any kind of clay products.

Near the mouth of a ravine in the northwest quarter of section 17, coal VIa is exposed above drainage, the following strata being visible:

	<i>Feet.</i>
1. Brown to drab clayey shale.....	5
2. Blue clayey shale.....	10
3. Black sheety shale.....	4
4. Coal VIa with parting.....	1

We have here 15 feet of good material for vitrified products with coal VI of workable thickness and its under-clay below.

A bore on the Kellar farm, in the southwest quarter of section 15, near a spur of the Vandalia Railway, showed 13 feet of under-clay and gray shale above, and three feet of under-clay beneath coal VI. As a rule, this coal is underlain by three to four feet of under-clay which is, however, not of as good quality as that beneath coal IV to the east.

Township 11 North, Ranges 6 and 7 and Part of 5 West.

This area, embracing 96 square miles, comprises the civil townships of Washington, Sugar Ridge and Perry. Coal VI covers the surface of the western two-thirds of Perry, while east of this coals I to V, with accompanying strata of shales and under-clay, occur. In that portion of 11 north, 5 west, embraced in Clay County, there is little commercial clay of value. It is possible that the under-clay below outcrops of coals I and II will, in a number of places, be found suitable for potters' use. In section 18, just northeast of Bowling Green, three feet of this blue shaly under-clay occurs beneath coal I, here only six inches thick. The same thickness of clay occurs beneath coal I on the Buell place in section 7, two miles north of Bowling Green.

In the vicinity of Centre Point, close to the northern line of Sugar Ridge Township (11 N., 6 W.), are a number of exposures of drab to blue clayey shale, which will be found suitable for making many kinds of clay products. Just northwest of the town, in the southeast quarter of the southwest quarter of section 4, on a 100 acre tract belonging to C. W. Mace, a test shaft, 4x6x34 feet was sunk in 1903 to determine the quantity and quality of the underlying clays. A section of this shaft shows:

Section of Test Shaft Near Centre Point.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil	0	6
2. Yellow surface clay.....	5	0
3. Soft to hard sandy shale and sandstone.....	6	0
4. Blue clayey shale.....	17	10
5. Coal IV	2	9
6. Under-clay	3+	0

The blue clayey shale, No. 4, is of the same character as that used in several of the larger clay factories at Brazil, being a very fine grained material, free from all grit, and when weathered or ground and moistened furnishes a plastic clay, suitable for the best of paving brick, sewer pipe, dry pressed or stiff mud facing or ordinary brick, and similar products. In the making of brick of any kind from it, much of the overlying surface clay and sandy shale could be used. If sewer pipe or hollow brick be made the shale will be best used alone or mixed with one-quarter to one-third its bulk of the under-clay No. 6. The latter is a soft dark gray plastic material, fit for hollow building block, terra cotta and stoneware. In the shafts of neighboring mines it runs five feet or more in thickness, and will doubtless be found of that thickness on the tract under consideration. The test shaft is but a few hundred yards from a spur of the Vandalia Railway and one and a fourth miles east of the Brazil Division of the E. & I. Railway. Water in quantity can be secured in wells at an approximate depth of 450 feet.

Along a branch of Hog Creek, on the farm of W. T. Jenkins, about two-thirds of a mile southeast of Centre Point are numerous exposures of a drab to blue clayey shale overcapped with 12 to 15 inches of gray sandy shale. One bore showed the blue shale to be 11+ feet in thickness, and it evidently occurs over a large area on both sides of the stream. In most places one to three feet of yellow clay overlie the sandy shale capping. This deposit can be easily reached by a spur of the Vandalia down the creek valley.

In the southwest of the southwest of section 3, just east of Centre Point, the same clay shale stratum outcrops seven feet thick on the land of H. B. Rogers. It lies just over coal IV, which is here just at or above drainage. Another exposure occurs in and just above the ditch on the west side of the road leading

from the Vandalia station to the town. This material can be easily secured and will be found suitable for clay products of many kinds. The same stratum is also said to outcrop in the northeast quarter of section 9, along the branch of Hog Creek just south of Centre Point, but I did not see this exposure.

By the side of a spur of the Vandalia Railway, three-fourths

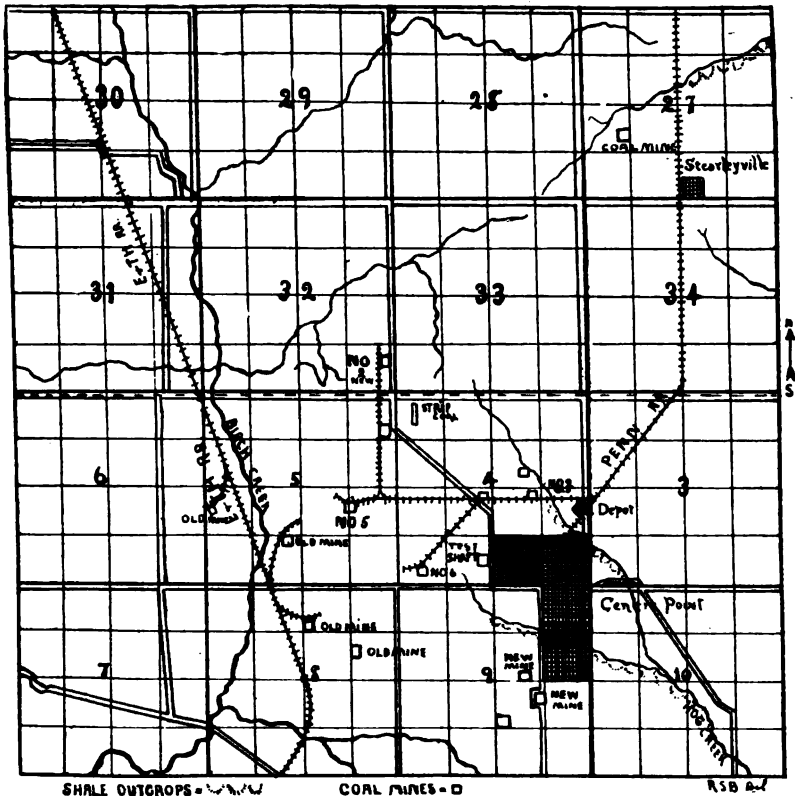


Fig. 9. Map of Centre Point and vicinity, showing shale deposits.

of a mile west of Centre Point and one-third of a mile west of the test shaft above mentioned, is the abandoned shaft of the old Louise Mine. A large amount of under-clay has weathered out on the dump, and a thick bed of shale was visible above the top vein of coal in the sides of the old shaft opening.

One-fourth mile west, in the northeast of the southeast of section 5, on the same spur of the railway, is the No. 5 mine of Crawford & Co. A section of the shaft showed:

Section of Crawford No. 5 Mine, near Centre Point.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil and surface clay.....	2	0
2. Blue clayey shale.....	18	0
3. Coal IV	3	6
4. Under-clay	3	0
5. Black bituminous shale.....	7	0
6. Coal III	3	0
7. Under-clay	2	0

Nos. 2, 4 and 7 are of good quality for vitrified clay wares, No. 5 being the fine grained, dark blue material found in the test shaft. The under-clay, No. 4, from this point, if properly washed, would make good stoneware. It will also be found excellent for terra cotta and hollow building block. No. 5 is much harder and darker, and would be suitable only for sewer pipe or, mixed with shale, for paving brick.

On the Butts place, in the northwest quarter of section 5, coal III has been stripped, a section at the pit showing:

Section on Butts Farm, near Centre Point.

	<i>Feet.</i>	<i>Inches.</i>
1. Surface	4	0
2. Shale	10	0
3. Coal III	3	0
4. Under-clay	4	0

Both shale and under-clay are suitable for manufacturing purposes.

On the Wm. T. Jenkins farm, three-quarters of a mile south of Centre Point, in the southwest quarter of section 9, a bore for a new gin shaft showed:

Section on Jenkins Farm.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil and yellow clay.....	9	0
2. Gray sandy shale and sandstone.....	4	6
3. Blue clayey shale.....	14	6
4. Coal IV	3	0
5. Under-clay	3+	0

About 18 inches of under-clay No. 5 have to be removed for height. Both it and shale No. 3 are of the same nature as similar strata in the test shaft. The coal is leased at a royalty of 10 cents per ton, and sells for \$1.90 at the mine.

Enough information has been given to show that Centre Point is surrounded on every side by shales and under-clays well worthy of development and manufacture. These clays are underlain with an excellent quality of block coal, than which no better fuel for their burning is in existence. Spurs from railways run directly to or are within a few hundred yards of many of the best deposits. Plentiful water can be had for the drilling. There is no known reason, therefore, why the town should not be the center of several clay industries of large size.

In the vicinity of Ashboro, on the E. & I. Railway, in the north half of section 17 (11 N., 6 W.), coal has been mined for many years. A section at the Floaterman gin shaft, northwest quarter of 17, will serve to show the sequence and thickness of the strata in the region of the town:

Section at Floaterman Shaft, near Ashboro.

	<i>Feet.</i>	<i>Inches.</i>
1. Surface soil and yellow clay.....	9	0
2. Blue to gray clayey shale.....	19	0
3. Coal IV	2	6
4. Under-clay	2	8
5. Gray shaly sandstone merging into shale.....	14	10
6. Coal III	3	0
7. Under-clay	2+	0

Of the strata given, Nos. 2, 4 and 7, and the lower portion of 5 could, if desirable, be made into many kinds of clay products.

In Perry Township (11 N., 7 W.), but little mining has been done. Coals VIb and VI lie near the surface over much of the area, but their accompanying strata are of little or no value for making clay wares.

The under-clay beneath coal IV, in the vicinity of Saline City, has in several places been mined and shipped to the Tiffany Enameled Brick Co., at Momence, Ill. In answer to an inquiry regarding this clay the manager of the Tiffany Company plant, made the following statement: "We have been able to get clays from Saline City and Clay City that mixed with other clays from Illinois have proven fairly satisfactory for the manufacture of our dry-pressed enameled brick, but these are by no means ideal, for the reason that they do not stand as high fire, without warping of the bricks, as we should like to put them to. In 1904, we

used about 7,800 tons of the clay from the two places. This cost us about 60 cents per ton, f. o. b. at the mines. The clays make good pressed brick but need to stand more fire for enameled brick."

Township 10 North, Range 7 and Part of 6 West.

This area of 60 square miles is mainly covered with coals II to V, and their accompanying strata. The greater part of section 31 (10 N., 6 W.), just south of Clay City, is a large hill or outlier of which the surface is 92 feet above the E. & I. Railway at Clay City. In this hill coal VI, with its overlying stratum of sandstone, occurs.

One mile northwest of Clay City on a switch of the E. & I. Railway, in the southwest quarter of section 19, is an abandoned coal shaft of the Brier Block Coal Company. Coal IV was formerly mined here at a depth of 117 feet. The vein averaging but three feet three inches in thickness, about 16 inches of the under-clay was removed to make height. The proprietors worked up a good market for this clay, having during one year sold over 9,000 tons of it at 90 cents per ton on board the cars. It was, while mined, used as the main body clay of many of the wares made by the Encaustic Tile and Terra Cotta Works at Indianapolis. It was also shipped to Chicago and Cincinnati, where it was made into ornamental brick, fire brick and terra cotta. Some very handsome tile brick made from this clay by Tiffany & Co., of Chicago, are on exhibit at the rooms of the Clay City Commercial Club. This clay has essentially the same properties as the under-clay of similar horizon at Brazil. When ground and wet it becomes a very close plastic material, well suited for the uses to which it has been put. Immediately over the block coal at this mine are 27 feet of blue clayey shale, the upper two-thirds of which can be made into vitrified products. While the coal has been worked out, much of the clay yet remains in this mine and is still available.

A stoneware pottery was established at Clay City in 1846, and has been operated continuously since.* For many years the clay has been obtained from a pit one-third of a mile farther south, in the northwest quarter of section 32 (10 N., 6 W.). This clay

*For further information concerning see under section IV.

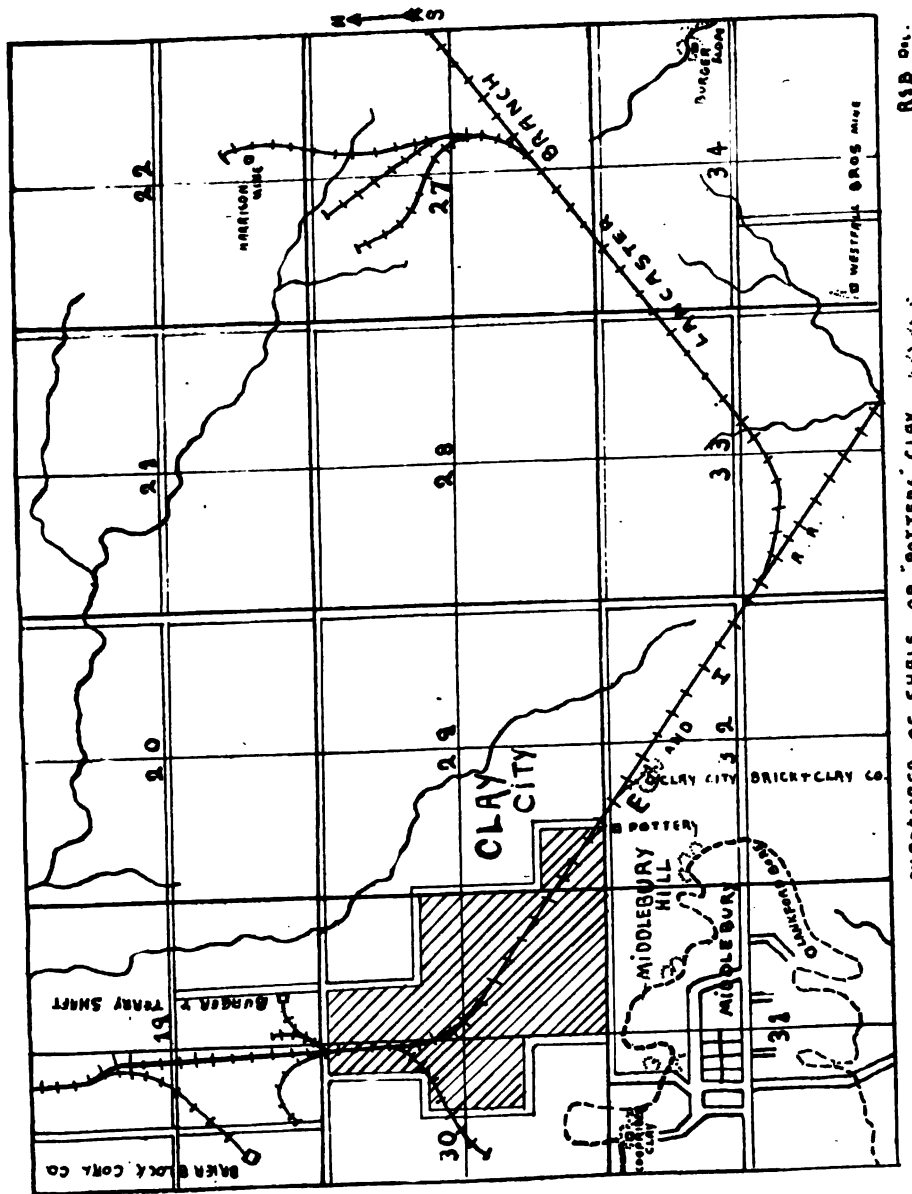


Fig. 10. Map of Clay City and vicinity, showing location of shale and clay deposits.

is the outcropping under-clay of coal VI, and is obtained by stripping six to eight feet of soil and surface clay, beneath which it lies in a stratum three to five feet in thickness. Underlying this is a reddish, rotten sandstone of unknown depth. Crystals of gypsum (selenite) occur in some parts of the clay deposit, but not in sufficient numbers to prove harmful. This clay is, when washed, very light, almost white in color, has good refractory properties and is one of the best potters' clays in the State. Burned in a regulation down draft kiln it does not air-crack while cooling. It was formerly used in quantities in the pottery in West Indianapolis, several thousand tons having been shipped there. It brought \$1.00 per ton on board the cars at the pit. The same stratum of clay outcrops at several other points around Middlebury Hill south and southwest of Clay City, and can be obtained in any desired quantity for stoneware manufacture.

For a time Mr. Griffith, the present potter, secured his supply of clay from the land of Robert Guthrie, three miles southeast of Clay City, and a fourth of a mile from the E. & I. Railway. At this point a good potters' clay is secured with but little labor from beneath a thin seam of coal, where it is found in a stratum three and a half feet in thickness.

One-half mile north of Clay City, in the southeast quarter of section 19, on the Burnham farm is the mine of Burger & Terry. Coal IV is here found 70 feet below the surface, a section at the shaft showing:

Section of Shaft of Burger & Terry Mine.

	<i>Feet.</i>	<i>Inches.</i>
1. Surface and boulder clay.....	30	0
2. Gray to buff sandstone.....	16	0
3. Blue clayey shale.....	24	0
4. Coal IV	3	6
5. Under-clay	4	2

The under-clay, No. 5, is richer in silica and therefore more refractory than that at the Briar Block mine. Mixed with the potters' clay found in the vicinity, in the proportion of one part to two, its quality is improved for stoneware purposes, the mixture producing a strong, close textured ware which does not air-crack and which stands up well under great heat.

By the side of the E. & I. Railway, two-thirds of a mile south-

east of Clay City, in the northwest quarter of section 32 (10 N., 6 W.), is the new plant of the Clay City Brick and Clay Company. This company began, in September, 1903, to make stiff mud ordinary brick and drain tile from a mixture of shale and overlying surface clay. A section at their pit and slope shaft, 200 feet west of the plant, showed as follows in June, 1904:

Section at Pit of Clay City Brick & Clay Company.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil and yellow surface clay.....	15	0
2. Blue clayey shale.....	16	0
3. Coal V	2	10
4. Under-clay	8	0

After stripping one foot of soil, the surface clay and shale are mined and hauled by steam power up a steep tramway to the dry pan. The shale is a very pure light blue, fine grained material which, when properly manipulated and burned, will make a good grade of vitrified products, such as paving brick, sewer pipe, hollow block, etc. The under-clay is light gray and very siliceous, and will in time, be made into fire brick. The company had only ordinary square up-draft kilns in operation, and were making about 30,000 ordinary brick daily. These were light cherry red in color and of seemingly good quality. The plant is fairly well equipped with modern clay working machinery, and with a number of round down-draft kilns, could turn out higher grade vitrified products, the raw material being well worthy of being put to better use than the making of ordinary brick.

The under-clay, No. 4, of the last section outcrops close to the E. & I. Railway, in a ravine on the John Miller farm, about one-half mile southeast of the brick factory. At the point of exposure it is a tough, plastic material, suitable for terra cotta and hollow brick.

On the line between Clay and Owen counties, three miles east and half a mile south of Clay City, southeast of northeast of section 34 (10 N., 6 W.), an exposure of shale and under-clay occurs on the land of Fred. Burger. At the point mentioned coal IV outcrops along a small stream and has been mined by slope shaft. A section of the exposure shows:

Section on Burger Farm, Southeast of Clay City.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil and yellow clay.....	3	0
2. Drab to buff shale.....	7	0
3. Coal IV.....	2	8
4. Under-clay	4+	0

The shale and under-clay are suitable for many kinds of wares. Both coal and under-clay outcrop in the branch 100 feet below the mouth of the slope. A spur of the E. & I. Railway runs within three-quarters of a mile of the outcrop.

At the Westfall Bros.' gin shaft, in the southwest quarter of the southwest quarter of 34 the following section was exposed:

Section at Westfall Bros., Shaft.

	<i>Feet.</i>	<i>Inches.</i>
1. Surface soil and yellow clay.....	6	0
2. Drab sandy shale.....	11	0
3. Coal	2	10
4. Under-clay	4+	0

About 18 inches of the under-clay is removed for height, and samples from the dump showed it to be a soft gray, unctuous and very plastic clay, suitable for terra cotta, encaustic tile, enameled brick, hollow building block, etc. This mine is a quarter of a mile north of the main line of the E. & I. Railway. This same under-clay and its overlying coal outcrops in the ravines over an area a mile square around this mine.

On the Croft, Jett, Moody and other farms in section 33 to the west, numerous bores have been sunk in search of coal, and nearly the entire section is under lease by the Brazil Block Coal Co. All of the bores show a three to four foot vein of under-clay below coal V when the latter is present, and usually a stratum of blue shale just above coal IV, with a five to seven foot vein of under-clay beneath the latter.

Around the slopes of the high hill already mentioned as covering the greater part of section 31, on which the village of Middlebury or Martz is situated, are a number of exposures of under-clay. Among them is the stratum of potters' clay above described as used at the Griffith pottery in Clay City. A connected section of a portion of this Middlebury hill is given by Ashley as follows:

Connected Section About Middlebury.

	<i>Feet.</i>	<i>Inches.</i>	<i>Feet.</i>	<i>Inches.</i>
1. Surface and drift.....	0 to 30	0	30	0
2. Sandstone	15	0	45	0
3. Coal VI	7	0	52	0
4. Under-clay	3	6	55	6
5. Sandstone and shale.....	8	6	64	0
6. Limestone or blue calcareous shale	7 to 3	0	67	0
7. Yellow shale	2	0	69	0
8. Black bituminous sheety shale.	4	0	73	0
9. Coal V	2 to 4	0	77	0

On the north slope of the hill, by the side of the road leading from Clay City to Martz is an outcrop of the potters' clay, No. 4 of the section, on the land of Wm. Mulsom. The outcrop is on the site of an old quarry where the limestone, No. 6, has been taken out for macadam. The potters' clay is here four feet thick with three to seven feet of yellow clay above it.

On the land of James F. Lankford, in the southeast quarter of section 31, a half mile southeast of Martz, and one mile southwest of the E. & I. Railway, a 200 foot bore has been sunk for coal, a partial section of which shows:

Section of Bore on Lankford Farm.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil and yellow clay.....	18	0
2. Sand and gravel	2	2
3. Blue clayey shale	9	4
4. Sand rock	2	0
5. Black bituminous shale	4	0
6. Coal	2	9
7. Under-clay	9	2
8. Sand rock	5	0
9. Gray shale	12	0
10. Coal	2	6
11. Under-clay	5	0

No. 7 is a light gray, very siliceous under-clay. Samples of it were sent to the Tiffany Brick Co., at Momence, Illinois, who reported it well suited for making enameled brick, encaustic tile, etc.

One-half mile northwest of Martz, in the northwest quarter of section 31, on the land of Chas. Coopridner, coal VI has been stripped on a slope of Middlebury hill and is now being mined

from a drift shaft. Where stripped it is said to have been in places 11 feet thick. The under-clay at the mouth of the shaft is nine feet thick and of good quality. Less than a quarter of a mile to the northwest a large area has been stripped on the slope of the hill to secure the limestone between coals VI and V for roadmaking purposes. Coal VI is here absent, but between the surface deposit of yellow clay, seven to 10 feet thick, and the limestone, is a stratum of potters' clay. Except where stained with iron oxide, by the leachings from the overlying yellow clay, it is very white and siliceous with an occasional glistening scale of mica visible. The stratum averages four feet two inches in thickness and rests directly on the worked bed of limestone, here five feet six inches thick. The stratigraphy shows this potters' clay to represent the partially weathered under-clay of coal VI. All the so-called potters' clays of the State are but under-clays of some coal seam. They occur in places where the coal is absent and are usually covered only by a few feet of alluvial or drift clays. Having been exposed for centuries to the leaching waters from the overlying material, they have undergone a process of natural washing which has rid them of many of their impurities and left them very light in color and exceedingly plastic, fit in every way for the manipulation of the potter.

An analysis of a sample of this potters' clay as it came from the deposit, made for this report by Dr. Lyons, shows its chemical constituents to be as follows:

Analysis of Potters' Clay from Land of Chas. Coopridger, Martz, Ind.

Silica (SiO_2)	75.57	
Titanium oxide (TiO_2).....	.85	
Alumina (Al_2O_3)	13.97	
Water	4.47	
		<hr/>
Clay base and sand.....		94.86
Ferric oxide (Fe_2O_3).....	1.47	
Lime (CaO}) .....	.95	
Magnesia (MgO}) .....	.71	
Soda (Na_2O}) .....	.46	
Potash (K_2O)	1.77	
		<hr/>
Fluxes		5.36
		<hr/>
Total		100.22

From what has been written it will be seen that within a radius of two or three miles of Clay City are numerous thick deposits of shales, under-clays and potters' clays, suitable for making the best of many kinds of clay wares. Coal occurs either above or below these clays in quantity sufficient to burn them. The E. & I. Railway, with terminals at Evansville and Terre Haute, passes within a short distance of all the principal deposits; while the Indianapolis Division of the Monon, to be finished in 1906, will offer a ready outlet to the east and north. Good water is available in abundant supply. Clay City has a population of nearly 2,000, and its Commercial Club is willing and anxious to secure factories to develop these dormant clay resources. All persons seeking sites for clay working factories are invited to investigate personally any or all of the deposits herein briefly described.

As has been shown, deposits of shale and clay cover a large area of Clay County, and suitable locations for factories for their utilization are abundant. Those already erected in the vicinity of Brazil have proven the clays fitted in the highest degree for the making of many products. Their orders during the past ten years have for the most of the time been booked for months ahead, and the trade has so far been worked up only in small areas of the states of Michigan, Illinois and Indiana. The sewer pipe and paving brick industries were scarcely affected by the panic of 1893-1894, as many cities kept their unemployed workmen engaged in street repair, and the demand for those products was increased rather than diminished. Taking everything into consideration, there is no reason why Clay County should not become as noted for her clay industries in the future as she has been for her deposits of block coal in the past.

OWEN COUNTY.

. Occupying an area of 398 square miles southwest of the center of the State, is Owen, a county rich in undeveloped mineral resources. It lies south of Putnam, east of Clay, north of Greene and west of Morgan and Monroe counties. The county is irregular in shape, its maximum length being 21 miles from north to south. Its northern third is 17 miles wide from east to west, while the southern two-thirds is 20 miles in width.

The Geological Epochs represented in the county are seven in number, viz., the Knobstone, the Harrodsburg, Bedford Oölitic, Mitchell and Huron limestones of the Lower Carboniferous, and the Mansfield Sandstone and Coal Measures of the Carboniferous Period.

The Lower Carboniferous rocks form the outcropping strata over much of the eastern part of the county and are most readily recognized by the presence of heavily bedded limestone. This limestone at places immediately underlies the Coal Measures; at other places there is a considerable thickness of shale or sandstone between. The Knobstone and Harrodsburg limestone occur only along the eastern border of the county; the former outcropping along the bluffs of White River near Gosport; the latter being found over an area of several square miles above and below that town, and also over a small area in the northeastern corner of the county. The Bedford Oölitic limestone forms the surface of several parts of sections just to the west of the Harrodsburg and has been quarried extensively at Romona and near Spencer. The Mitchell is the predominating limestone over the eastern half of the county and has been used in a number of places for macadam purposes. The Huron limestones and sandstones are exposed mainly along the streams of the western half, where the overlying Mansfield sandstone has been eroded from above.

The Mansfield sandstone forms the surface of irregular patches or tracts of the higher land in the western half. These table lands often cover an area of a dozen or more square miles and are characterized by possessing a less fertile soil than that above the limestones. The Coal Measure rocks proper, lap over the western edge of the southern part of the county, covering an area of 15 to 18 square miles north and south of Coal City, and also a very irregular tract of eight or ten square miles in the vicinity of Patricksburg.

In the northeastern part of the county, near Quincy, the surface is rolling, the valley of Eel River broad, level and shallow. From the northwestern to the southeastern corner stretches a belt of high hills or ridges and deep, narrow valleys, the ridges rising 150 to 250 feet above the valleys and up to 300 feet above White River. To the southwest the hills become lower and

broad, with broader valleys between. All but the southeastern corner of the county lies in the drift area. Over its hillier part the drift is shallow or wanting, so that it interferes but little with observing the rocks. Towards the northern and southwestern parts the drift increases in depth; but still probably averaging less than 20 feet and not often running over 30 feet in thickness.

The principal stream is the West Fork of White River, which flows across the southeastern corner of the county from northeast to southwest. Its tributaries are Mill, Rattlesnake and Fish creeks from the north, and McCormack's and Raccoon creeks from the south and east. The South Fork of Eel River, rising near the northeastern corner of the county, flows west or northwest and joins the main or North Fork in the southwestern corner of Putnam County. It then swings around through eastern Clay County and, after receiving the Jordan, Six Mile and Lick creeks, crosses the extreme southwestern corner of Owen County, flowing a little south of east. All these streams furnish ample drainage and have, by their erosion, rendered the greater part of the surface of the county very rough and broken.

Three railroads, the C., I. & L. (Monon), the I. & V., and the E. & I., cut across, respectively, the northeastern, the southeastern and the southwestern corners, leaving the center and northern parts wholly without facilities for transportation. However, the Indianapolis Divisions of both the Southern Indiana and the Monon have been recently surveyed through the northern third and there is little doubt but that one or both will soon be constructed.

Township 11 North, Ranges 3, 4 and Parts of 2 and 5 West.

The Knobstone shale, which forms the oldest surface rocks in Owen County, is exposed north of Gosport in a bold bluff for nearly half a mile just south of the junction of the "Monon" and I. & V. Railways. This exposure is on the lands of Dr. John W. Smith and Major A. H. Wampler, in the northeast quarter of section 31 and the northwest quarter of 32 (11 N., 2 W.). The shale is here grayish blue in color, free from lime and iron impurities, and with the proper manipulation will make a good article of pressed front brick or vitrified paving brick. Sample brick

from a similar material at Martinsville, Ind., made by Boyd, White & Co., of Chicago, are unexcelled in general appearance. The railway facilities at Gosport are excellent; cheap fuel can be obtained from the mines of Greene and western Owen counties; and an abundant supply of water in White River.

In the vicinity of Gosport are also many deposits of the better grades of surface clays. In a ravine on the land of D. W. Buskirk, in the northern limits of the town, northeast quarter of section 31 (11 N., 2 W.), is an outcrop of yellow clay which by excavation has been shown to be eight feet in thickness. It is much lighter colored and finer grained than the ordinary surface clays of the surrounding hills, and judging from appearances will make a good dry pressed front brick. To the west it becomes more siliceous and approaches in character a fire-clay. The surface clays overlying the outcropping Knobstone shales, as well as the shales themselves, are suitable for ordinary soft mud brick, and the mouth of the ravine, between the deposit of yellow clay above mentioned and the two railways, presents an attractive location for a combination plant, capable of making both dry-pressed and ordinary brick.

Accompanying coal I, in the Mansfield sandstone area of the northern third of Owen County, occur some deposits of potters' clay and shale which, when the new railways are opened up, will prove of value. The most available of these, and the only ones examined for this report, are located in the vicinity of Cataract, in township 11 N., 4 W.

One-third to one-half mile southwest of Cataract, on the land of Dr. J. M. Jones, southwest quarter of the northeast quarter and the east half of the northwest quarter of section 2 (11 N., 4 W.), are some deposits of a fine grade of potters' clay and some good shale. A connected section of the strata of the vicinity shows:

Section on Land of Dr. Jones, near Cataract.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil and surface clay.....	2	0
2. Sandstone	20	0
3. Coal I	0	2
4. Under-clay	7	6
5. Soft blue clayey shale.....	7	0
6. Drab sandy shale	8	0
7. Three thin bands of ironstone.....	0	7
8. Blue clayey shale	7+	0

On the north slope of a high hill, in the east half of the north-west quarter of 2, the under-clay No. 4 is exposed in the gullies and is covered only by two to three feet of soil and drift, over quite an area. It is a soft, very light gray to white, plastic, potters' clay; is wholly free from grit and other impurities, and will make an excellent grade of stoneware. According to Dr. Jones, this stratum of under-clay extends a half mile or more to the north without rock or other heavy cover above it.

To the southeast, on the north side of the east-west road, the shales Nos. 5 and 6 are exposed to the thickness mentioned in the section. The upper blue shale is a soft, fine-grained, clayey shale, very plastic when weathered. Numerous small nodules of kidney iron ore are weathered out on its surface, the lighter particles of shale from around them having been carried down the slope by eroding waters. This shale will make sewer pipe and hollow building block, or, mixed with one-third its bulk of the sandy shale below it, a good grade of paving or dry pressed brick. Shale No. 6 is too sandy to be used alone, but can be ground up with either the overlying or underlying stratum and made into many kinds of products.

The lower shale, No. 8, is exposed by the side of the stream near the road at the base of the hill to a thickness of 7 feet. It is of a fine quality of clayey shale, a little more siliceous than No. 5, and suitable for all kinds of vitrified wares. Just over it are three bands of siderite, or kidney iron ore, each two to four inches thick, and over these at the point mentioned about two feet of yellow clay. These shale deposits also come close to the surface over the north half of the southwest quarter of section 2, on the south side of the road.

Three-fourths of a mile southeast of Cataract, on the land of Rev. D. T. Poynter, west half of the northeast quarter of section 1, the following exposure is visible by the side of a small tributary of Eel River, the latter stream being one-fourth mile to the east:

Section on Land of D. T. Poynter.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil	0	4
2. Iron ore band (siderite).....	0	3
3. Sandy shale	12	0
4. Coal—two thin bands	0	$\frac{1}{2}$
5. Under-clay	2	0
6. Soft blue clayey shale.....	7+	0

Of these No. 3 is too siliceous to be used alone, but could be mixed with both Nos. 5 and 6. Some trouble might be experienced with sulphur, as numerous small crystals of pyrites were visible in the under-clay. The blue shale is of good quality for many wares.

Mr. Poynter states that the under-clay comes close to the surface in several large fields on his farm, and, being practically impervious, whenever it rains the water is held for a long period in the overlying soil, and renders it difficult to cultivate.

On the land of W. E. Meek, northeast quarter of section 10 (11 N., 4 W.), two and a half miles southwest of Cataract, just southwest of the junction of the Cataract and Vandalia and Cataract and Bowling Green roads, the same shales and potters' clays were exposed as were noted as occurring on Dr. Jones' land. The potters' clay and sandy shale are exposed in ditches by the roadside just south of the road junction, and the lower, plastic blue shale in a ravine 200 yards to the southwest, where it outcrops four feet thick, with a foot or so of drift above it. These shales and under-clay accompanying coal I evidently have a wide distribution in this region, and will eventually be used for manufacturing purposes.

On the Evans farm, in the northeast quarter of section 11 (11 N., 4 W.), the following strata are exposed, according to Collett:*

Section at Evans' Farm.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil and surface	16	0
2. Yellow sandstone	8	0
3. Blue shale with ironstone.....	10	0
4. Black shale	0	8
5. Under-clay	2	0
6. Coarse sandstone	28	0
7. Massive gritty sandstone, white and yellow....	30	0
8. Soft white sandstone	3	6
9. Blue clay shale	12	0
10. Band of kidney iron ore.....	0	8
11. Black clod or clay.....	1	10
12. Coal I.....	1	8
13. Blue shale with iron ore.....	12	0
14. Kaskaskia limestone in creek.....	11	0

*Seventh Ann. Rep. Geol. Surv. Ind., 1875, 342.

This point was not visited by me, but from the description I judge Nos. 3, 5, 9 and 13, aggregating 36 feet in vertical thickness, to be suitable for clay working purposes. The iron ore, mentioned as occurring in 3 and 13, is evidently the kidney concretions of siderite found in nearly all shale deposits.

Township 10 North, Ranges 4, 5 and Part of 6 West.

The more valuable deposits of clays and shales of Owen County are found in townships 9 and 10 north, ranges 6 and 7 west. Here are located the principal coal veins; in fact, the only ones of value in the county, together with their accompanying shales and under-clays.

In the western part of Spencer, the county seat, Woods Bros. made, for 30 years, a good quality of ordinary brick and drain tile from a yellow loamy surface clay, after stripping four to six inches of soil. The same firm also made flowerpots and kindred wares from an under-clay obtained at Powell's hill, four and a half miles west of Spencer. About \$2,500 worth of these products were made in 1903. On account of financial trouble, the plant changed hands and was not run in 1904, and during that year there was not a clay product of any kind made in the county.

On the land of T. J. Blakemore, in the southwest quarter of 23 (10 N., 4 W.), three miles west of Spencer, is an outcrop of six to eight feet of blue shale in a ravine, the bottom being hidden. The shale is light blue in color, very fine-grained, and when ground and moistened will form a tough, plastic material, suitable for vitrified brick, sewer pipe, etc.

In the northeast quarter of section 13 (10 N., 5 W.), two and a half miles east of Patricksburg, is a case of the Mansfield sandstone being replaced by shale. In the northwest of the northeast is an exposure of massive sandstone 12 to 15 feet thick. Toward the east the sandstone thins out. On the west side of the drain, near the township line, a drift was driven a short distance under the sandstone, but no coal was struck. A well in the bottom of the branch just above this went through 50 feet of blue shale. The road from the branch to the top of hill 50 to 60 feet above shows gray shale all the way, making a thickness of 100 to 110 feet of workable shale.

In the immediate vicinity of Patricksburg the lower block coal III is found close to the surface in thick veins of great purity. On the land of John Andrews, one-half mile southeast of Patricksburg, on the northwest quarter of the southeast quarter of section 15 (10 N., 5 W.), a slope mine has been worked for some years. A section at this point shows the presence of the following strata:

Section at Andrews Mine, South of Patricksburg.

	<i>Fest.</i>	<i>Inches.</i>
1. Surface and yellow drift clay.....	5	
2. Blue gray clayey shale	21	
3. Coal III.....	5	2
4. Under-clay	4	3
5. Sandstone	31	

The deposit of shale above the coal is one of the best I have seen in the State. It is of very fine texture, free from grit and all traces of nodular iron ore. It is very similar to the seam worked at Brazil into sewer pipe and other products. The under-clay below the coal is, however, inferior in quality, containing a large percentage of pyrites and other impurities and presenting a shaly or laminated appearance.

A short distance north of Patricksburg, in the southwest quarter of section 10, are two slope mines where the same shale is exposed to a thickness of 16 to 20 feet. The coal in these mines is over four feet thick, pure non-caking block, equal to the best in this or any other State. Both fuel and clay are here present in almost inexhaustible quantity. The one thing lacking is a railway spur by which these resources or their manufactured wares can be carried to the points where needed.

The horizon of coal I is found from 25 to 40 feet below that of III, and the vein outcrops in many places north and northeast of Patricksburg. The under-clay of this coal is from three to four feet in thickness, of good quality and suitable for terra cotta, and in many places for potters' wares.

Down the Lick Creek Valley, southwest of Patricksburg, the shale overlying coal III comes to the surface in a great many places. A railway from Woodside could be easily constructed up this valley to Patricksburg, and so open up the way for developing many of these deposits of shale and underlying coal.

On the William Norris place, in the southeast quarter of section 21, two veins of coal occur, a section of the exposure being as follows:

Section on the Norris Farm, Southwest of Patricksburg.

	<i>Feet.</i>	<i>Inches.</i>	<i>Feet.</i>	<i>Inches.</i>
1. Soil	10	0	10	0
2. Gray shale	4	0	14	0
3. Coal IV	5	0	19	0
4. Shale and iron ore.....	30	0	49	0
5. Coal III	2	2	51	2

Just across the line, in the northwest of northwest of section 28, coal III has been mined on the Devin place, formerly the Sinks place. At an open drift the coal measured two feet ten inches in thickness. It is a semi-block to block, showing the slips and splitting readily along the dull bands. Above it is 12 feet of brown to blue shale, suitable for clay wares.

Near Woodside, or "Lancaster," in the northwest of section 26 (10 N., 6 W.), are several mines from which the well-known "Lancaster Block" coal is secured. An average section at these mines shows:

Section near Woodside or Lancaster.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil and yellow clay.....	8	0
2. Blue shale	13	0
3. Coal IV	4	0
4. Under-clay merging into sandstone.....	4	0
5. Brown to black shale.....	10	0
6. Coal III	3	6
7 Under-clay	10	0

The shale overlying coal IV is here 13 feet thick. The upper eight feet could be utilized, but the lower part contains too much bitumen. The under-clays Nos. 3 and 7 are both of good quality for terra cotta or hollow building block. Only coal IV has been worked. These mines are located on a spur of the E. & I. Railway.

About 1887 John Andrews erected a factory at this point for the purpose of making fireproofing, vitrified drain tile, brick, etc. The machinery with which it was furnished was old-fashioned and the kilns constructed were patterned after those used in Scotland two centuries ago. As a result the enterprise proved a failure, and nothing has been done since 1895. From \$10,000

to \$12,000 were sunk, one-half enough to have fitted the factory up in good shape with the latest improved machinery. All the essentials of a successful clay industry are present, and a plant constructed and carried on in modern style would doubtless prove remunerative; but Old World methods of a century or more ago cannot compete successfully with those of the present age.

One and a fourth miles south of Woodside, in the northwest quarter of section 35 (10 N., 6 W.), is the Berger slope shaft, where coal IV is reported to average four feet, ranging from three feet six inches to four feet six inches, without parting. Near the south line of the same section are the Crouse, Leohr and Harbough drifts, on coals IV and III, the two coals here being about 12 feet apart. The upper coal is said to range from three feet six inches to four feet, with a blue shale roof and fire-clay under. The lower bed is said to run from two to three feet, being a fine quality of block coal. The interval between the beds is composed of a good quality of shale for vitrified products.

Township 9 North, Ranges 3, 4, 5 and Part of 6 West.

Among the jars of clay in the State Museum, collected by former State Geologist S. S. Gorbý, is one filled with very fine white kaolin, and having on the label the name of J. H. Ward, Spencer, Ind. No other data accompanied it, and no such person is known in the vicinity of Spencer. That deposits of kaolin similar in quality to that of Huron, Lawrence County, occur in Owen County has long been known, yet but little has been done toward their development.

An outcrop occurs on the land of Mrs. Hopewell, five miles southeast of Spencer, section 12 (9 N., 3 W.). A slope shaft was put in a short distance a few years ago, and excellent samples obtained. A visit to the place showed that the opening had been closed by the soil washing down over it. A quantity of the kaolin, stained by iron oxide, was lying near, but no specimens of the better grade were secured. In the Geological Report for 1875, p. 359, Prof. Collett mentioned a similar outcrop as occurring in the northeast quarter of section 7 (9 N., 3 W.), four miles west of the one above mentioned. The kaolin probably underlies

the greater portion of 9 north, 3 west, but the thickness and quality of the stratum can only be determined by a more extensive investigation of the known outcrops.

One and three-fourth miles southwest of Freedom, on the land of John McIndoo, northeast quarter of section 32 (9 N., 4 W.), is a large deposit of pinkish red clay which lies near the surface. The first outcrop visited was by the roadside about one-eighth of a mile north of the I. & V. Railway, where the vein of this clay has been proven by digging to be six feet in thickness and overlain with from five to seven feet of soil and yellow clay. Farther north and west it extends over quite an area, and in places on the lands of A. J. Nelson and James Patterson it has been stripped and shipped for a number of years to the U. S. Encaustic Tile and the Terra Cotta Works, at Indianapolis; the National Tile Company, at Anderson, Ind., and to Newark, N. J. Probably 1,500 carloads have been sold, the clay being hauled in wagons a mile and a quarter to Farmers' Station, where it brought from \$1.50 to \$2.00 per ton on board the cars.

This is one of the high-grade commercial clays of Indiana, being very fine-grained and in most cases free from grit and gravel, tough and exceedingly plastic. Streaks of a whiter color occasionally run through it, which, when present in any quantity, deteriorate its value for the uses to which it is at present put. That found on the McIndoo land, above noted, contains fewer impurities than at any other exposure visited, and it is more accessible to a railway.

A deposit of similar clay has been recently uncovered on the land of Zach. Messick, southwest of southeast of section 29 (9 N., 4 W.), one and a half miles northeast of Farmers, on the north side of the Farmers-Freedom road. This exposure, in June, 1904, showed five feet of soil and yellow clay, overlying five or more feet of the pinkish red clay, the bottom of the latter stratum not being reached. The lower part of this pit showed the clay as shipped to be a decomposed shale, as the laminæ or layers of pinkish shale, an inch or two thick, were plainly visible at a depth of eight or more feet from the surface.

On the land of J. R. Payne, near the center of section 29, the same clay outcrops in a ravine. In a well a few rods east of this outcrop the following section was exposed:

Section on Land of J. R. Payne.

	<i>Feet.</i>	<i>Inches.</i>
1. Surface and yellow clay.....	10	0
2. Blue argillaceous shale	14	0
3. Pinkish red plastic clay.....	?	0

This would also go to prove that the pinkish clay is a decomposed shale, and not a surface deposit, as has been formerly believed. This clay is used by the Encaustic Tile Company to mix with less refractory surface clays in the making of red floor tiling. It is too pure and refractory to use alone, twisting and shrinking out of shape under the influence of great heat. When it becomes more generally known it will probably be put to far more extensive use than at present.

On the land of Dr. A. B. Irwin, a mile and a quarter west of Farmers, and one mile from the I. & V. Railway, in the west half of the northeast quarter of section 36 (9 N., 5 W.), outcrops of under-clay, which has been weathered down into a good grade of potters' clay, occur in ditches along the roadside. These exposures are on the slope of a hill a few hundred yards west of the Irwin residence. A well near the house shows:

Section of Well at Residence of A. B. Irwin.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil and yellow clay.....	11	0
2. Sandstone	31	0
3. Black shale		3
4. Coal III	3	4
5. Under-clay	4+	

The under-clay No. 5 is, where exposed, a very white and plastic, siliceous material, suitable for stoneware, hollow building block, etc. It evidently underlies a large area in the vicinity, as outcrops also occur on the south and east slopes of the hill or upland tract.

At the Arney mine, in the northeast quarter of section 9 (9 N., 5 W.), both coals IV and III are mined. A gray clay shale, seven feet in thickness, overlies coal IV, which is here three feet four inches thick, while a gray siliceous shale, 11 to 13 feet thick, lies just above coal III.

At the Berger mine, in the northwest quarter of section 19, both coals are also worked, a section at the shaft showing 10 to

12 feet of shale above coal IV and 18 feet between it and coal III. These shales at both mines could be used profitably for clay wares in connection with the coal as fuel, were railway facilities present. The Berger mine is less than one mile east of the E. & I. Railway.

At the air shaft of an abandoned mine, 100 yards west of the E. & I. Railway, at Coal City, and but a short distance from the Clay County line, is an exposure of shale of good quality. This exposure is in the northeast quarter of the southwest quarter of section 11 (9 N., 6 W.), a record of the shaft showing:

Section of Air Shaft near Coal City.

	<i>Feet.</i>	<i>Inches.</i>
1. Surface and yellow clay.....	7	0
2. Blue clayey shale.....	28	0
3. Coal III	4	0
4. Under-clay	3	0

On the southeast of the southwest of the same section a bore was put down 94.8 feet through the vein of block coal. Of this distance 47 feet was composed of blue shale or soapstone.

For a number of years Mr. James F. Hyatt operated at Coal City one of the largest ordinary brick yards in Western Indiana. More than three millions per annum were made for part of the time. The clay used was the yellow surface clay, which is here free from lime and other impurities, and made a strong and lasting brick, which found a ready market in many of the towns of the adjoining counties. This clay at the yard of the old brick factory lies directly over the shale (No. 2) of the above section, and a combination plant for making both ordinary and vitrified brick could be operated which would doubtless prove a success.

Such are the more available and better known clay deposits of Owen County. As already noted, not one of these deposits was being operated in 1904. With raw material of excellent quality and fuel in close proximity for its burning both present, this condition is due to both a lack of energy and a lack of transportation facilities. The officers of the railways entering this region have not been far-seeing enough to put in spurs, at an expense of a few thousand dollars, to the better known deposits. As a result the larger clay factories of the State have been located in other

counties. Let us hope that the owners of the new railways which will soon open up the northern half of Owen County will show a more progressive spirit, and that at least one, if not half a dozen, clay industries of large size will soon be erected within her bounds.

GREENE COUNTY.

Lying near the center of the southwestern quarter of the State is the county of Greene, comprising a rectangle 30 miles long from east to west by 18 miles in width from north to south. It thus embodies an area of 540 square miles, which lies west of Monroe, south of Owen and Clay, east of Sullivan and north of Knox, Daviess and Martin counties.

The rocks of four different Geological Epochs form the surface of the county, viz., the Mitchell limestone and Huron Group of the Lower Carboniferous and the Mansfield sandstone and Coal Measures of the Carboniferous Periods. The Mitchell limestone comes to the surface only over small irregular areas in the northeast and southeast corners of the county. The limestones and sandstones of the Huron Group form the surface of the greater portion of the eastern half of the county, being exposed everywhere along the streams which have worn their way down through the softer overlying Mansfield sandstone. East of White River the latter formation occurs in very irregular isolated areas which comprise the crests of the higher ridges and hills of this section of the county. West of White River the Mansfield sandstone forms the surface of two large disconnected areas which lie adjacent to that stream, and are separated by a narrow tongue of the Coal Measures, which extends east to the river opposite Bloomfield. The Coal Measures proper are practically limited to the western third of the county, only three or four small isolated areas being found east of White River.

As already noted, the topography of this portion of the county is very broken. The divides are usually very narrow, as are the stream channels, with steep slopes between. As White River is approached the topography becomes less broken. West of the river are extensive marshlike prairies, evidently filled-up valleys, while the divides between are broad rolls rising from 25 to 75 feet above the level prairies. In the northwestern corner of the

county the stream channels are narrow, with rather steep banks, rising to narrow divides.

The county is divided into almost equal halves by the West Fork of White River, which flows in a southwesterly direction across its center. With the exception of the northwestern and southeastern corners, all of the drainage is into White River. The main branches from the east are Richland Creek, with its tributaries, Beech and Plummers creeks and Doans Creek, while from the west are Eel River, Latta's, Beech and Black creeks. Indian Creek, a tributary of the East Fork of White River, drains the southeastern corner, while the head waters of Busseron Creek extend up into the northwestern corner.

The eastern end of the county lies within the boundaries of the driftless area of the State. Over the uplands of the rest of the county the drift is generally met with, though usually less than a score of feet in depth. In the lowlands and prairies the deposits are found to be considerable, often over 100 feet in depth, these places evidently being old preglacial valleys, which have been filled up.

The western half of the county is exceptionally well supplied with transportation facilities. The Indianapolis & Vincennes Railway crosses this portion in a southwesterly direction, keeping west of and in the valley of White River. It also sends a branch to the Linton coal field and Dugger, in Sullivan County. The Evansville & Indianapolis Railway runs north and south across the center of the county, also following the valley of White River for much of the way. The Effingham Division of the Illinois Central, formerly the Illinois & Indiana Railway, runs to Switz City from the west, while from the same place the Switz City branch of the C., I. & L. Railway (Monon) runs southeast across the county. The Southern Indiana extends from Elnora to Linton and Terre Haute across the western third. Besides these, the Indianapolis Southern is being built from Switz City north-eastward, thus opening up a new area, and one or two other roads or branches are being planned to reach the Linton coal field.

The western third of Greene County has, within the past ten years, developed into one of the best coal-producing areas of the State. The best beds of shale and clay also occur in this area, being for the most part found west of the main line of the I. &

V. Railway, which follows approximately the western border of the Mansfield sandstone. In the eastern half of the county the sub-conglomerate coal I outcrops and is mined in a number of localities, but can nowhere be relied upon to supply more than a local demand. Beds of shale suitable for commercial purposes are rarely found above coal I, but the under-clay beneath it is oftentimes of excellent quality.

Townships 6, 7 and 8 North, Ranges 3 and 4 West.

This area of 216 square miles comprises the eastern two-fifths of Greene County, embracing all of Beech Creek, Center and Jackson townships and the eastern half of Highland, Richland and Taylor townships. The Switz City Branch of the Monon Railway crosses the southern third of the area, leaving the county at its southeastern corner. The Indianapolis Southern Division of the Illinois Central will soon be completed from east to west through its center. Coal I, with underlying clay, occurs in scattered localities over the greater part of the area, while coal III, also overlying a good under-clay, is found over portions of the three southwestern townships.

On the William Hanson farm, in the north half of the southwest quarter of section 2 (8 N., 4 W.), the semi-block coal I occurs 30 inches thick, with four to five feet of a good under-clay beneath. On the James Barnes farm, in the southeast of the southwest of the same section, the coal is three feet thick and with four feet of under-clay below. At both places the under-clay, when weathered or properly washed, will make good stoneware or hollow building block.

In the northwest of the northwest of section 29 (8 N., 4 W.) occurs, near the roadside, an exposure of blue to gray clayey shale, 15 feet in thickness, overlain with brownish flaggy sandstone. Coal I occurs beneath, probably in sufficient quantity to burn the shale into any one of a number of different kinds of clay wares.

On the land of J. L. Sparks, in the east half of the northwest quarter of section 6 (7 N., 3 W.), the horizon of coal I, here four to 30 inches thick, underlies the top of the ridges. Above the coal is eight to 10 feet of bluish gray sandy shale, while below it

a fair grade of under-clay, three to five feet in thickness, is found. The shale is too siliceous for use alone, but could be mixed with the under-clay for brick-making purposes. This point is about one mile north of the survey of the Indianapolis Southern Railway.

By the roadside, a quarter of a mile east of Cincinnati, in the northeast quarter of section 27 (7 N., 3 W.), is an exposure of the under-clay of coal I, which has been weathered into a good grade of light gray, very plastic, potters' clay. In gullies on the south side of the road the exposure is 5+ feet thick, with 3½ feet of yellow clay above. The latter contains numerous small nodules of iron carbonate, which, by erosion of the yellow clay, are left lying on the stratum of potters' clay. Good stoneware, hollow building block, terra cotta and other products could be made from this potters' clay, which will be found underlying the surface of the ridge running northeast and southwest, just east of Cincinnati.

Samples of a high-grade potters' clay were sent in to this office in 1900 from the land of Mrs. F. Weaver, on Indian Creek, southeast of Cincinnati, and about a mile and a half south of the Old Virginia Furnace. It is a very light gray, gritless plastic material, which can be used for the best of stoneware, pottery, terra cotta, encaustic tile, hollow vitrified wares, etc. I did not have time to visit the deposit, and was not able to ascertain the thickness of the clay nor the character of the overlying strata. The exposure is stated to be within 300 yards of the present survey of the Indianapolis Southern Railway.

On the land of A. J. Phillips, in the northwest of the northwest of 28 (7 N., 3 W.), one-half mile southeast of Tanner Post-office is a 14-foot exposure of a light gray sandy shale. Mixed with one-quarter its bulk of a more plastic and less siliceous material, such as the under-clay of coal I, it can be made into vitrified wares of different kinds, but probably contains too high a percentage of sand to work alone. The outcrop is along a small stream about one mile south of the survey of the Indianapolis Southern Railway.

By the roadside just south of Ridgeport, in the southwest quarter of section 13 (7 N., 4 W.), is an exposure of the weathered under-clay of coal I, which underlies the east-west ridge, a third

of a mile wide, on which Ridgeport is located. The outcrop at the point mentioned is five to seven feet in thickness in the gullies, and immediately underlies a heavy ledge of grayish sandstone, coal I being absent. It is a whitish, fine-grained, plastic material, free from iron stains and other impurities, and was used for a number of years in a small pottery at Ridgeport. The principal outcrop is on the land of Benj. Holtzclaw, one mile north of the Indianapolis Southern survey.

At the old Templeton mine, on the James Inman farm, northwest of southwest of 20 (7 N., 4 W.), coal III has been mined for 35 years from a slope shaft which opens beneath a heavy overhanging cliff of sandstone at the head of a deep ravine.

A section at the mouth of the slope shaft shows:

Section at Inman Mine.

	<i>Feet.</i>	<i>Inches.</i>
1. Slope, concealed	?	?
2. Flaggy sandstone	4	0
3. Sandy shale	8	0
4. Massive sandstone, iron spotted, cross-bedded....	25	0
5. Coal III	2	10
6. Under-clay	5	4

The under-clay, No. 6, is a high-grade material of its kind, being a light gray, tough and very plastic clay, free from grit, and suitable for hollow building block, flue linings, terra cotta, conduits, and all products of a similar class such as are made at the large factories about Brazil, Ind.

The same grade of clay occurs beneath coal III on the Sherman Allen farm, in the northeast quarter of section 28 (7 N., 4 W.). The coal is here 32 inches thick and, like that at the Templeton bank, is a semi-block coal of good quality for burning clay wares. The under-clay is said to run 7 to 10 feet in thickness, and contains occasional fragments of fossil plant remains. This exposure is less than a quarter of a mile south of the survey of the Indianapolis Southern Railway. Worked in connection with the coal, the under-clay at either the Templeton or Allen mines will well justify the installing of a large clay industry as soon as the railway furnishes an outlet.

Along the roadway by the side of the P. H. Fuller farm, in the north half of section 26 (7 N., 4 W.), is an exposure of light

gray shale, 15 to 22 feet in thickness. It evidently covers a large area to the north and south of the road, and has a light cover of surface clay above. From samples at hand it is judged that it can be made into sewer pipe, paving brick and kindred products. The point of exposure is half a mile south of the Indianapolis Southern survey.

A bed of good potters' clay is located on the land of L. J. Faucett, northeast of southeast of section 31 (7 N., 4 W.), one-half mile northwest of Mineral City, and but one-eighth of a mile from a switch of the B. & B. Railway. It is exposed by the side of a small stream, is five feet in thickness and covered with a layer of soil four feet in depth. This clay is grayish white in color and contains free silica in sufficient quantities to prevent air cracking when cooling. It has been tested in a pottery at WORTHINGTON and found in every way suitable for the making of the better grades of stoneware.

One-half mile south occurs an outcrop of shale in the side of a bluff of Plummer's Creek. The strata exposed at this point are as follows:

Section on Plummer's Creek.

	<i>Feet.</i>
1. Soil and yellow clay.....	10
2. Gray sandy shale	8
3. Sandstone	6
4. Soft, blue, clayey shale.....	8+

Shale No. 4 will make sewer pipe or paving brick of good quality. No. 2 contains too much sand to work alone, but can be mixed with the lower stratum and burned into ordinary or dry pressed brick.

On a hillside just west of Owensboro, and a short distance north of the Bedford & Bloomfield (Monon) Railway, in the northeast quarter of section 28 (6 N., 3 W.), is an outcrop of the under-clay of coal I, of excellent quality for the making of stoneware. It was long used for this purpose at the Reynolds pottery, which was located three miles southwest of the deposit. The clay stratum is between three and four feet in thickness, and can be reached by easy stripping.

At the east end of the Little Monon tunnel, northeast of southeast of 28 (6 N., 3 W.), the following section is exposed:

Section at East End of Little Monon Tunnel.

	<i>Feet.</i>	<i>Inches.</i>
1. Soft, dark shale	20	0
2. Heavy sandy shale with sigillaria	4	0
3. Bone coal I.....	1	0
4. Under-clay	3	0
5. Olive green shale.....	3	0
6. Soft dark drab clay shale.....	12	0
7. Shaly limestone and shale.....	3	0

Of the strata exposed, Nos. 1, 4 and 6 can be burned into a variety of vitrified products. Coal can be cheaply secured and the railway is on the spot.

On the J. D. Boruff farm, in the southwest corner of section 22, coal I, 18 to 21 inches thick, has nearly five feet of good under-clay beneath. At the John Rawlins drift mine, in the southeast quarter of 29, coal I, 18 to 26 inches thick, has a stratum of drab clay shale above and five feet of under-clay beneath. Both shale and clay can be utilized for clay wares.

One-half mile north of Koleen, on the north side of the valley of Plummer's Creek, is a high hill or ridge, on the side of which several strata of shale outcrop above and below the horizon of coal I. These outcrops occur on the land of R. C. Wright, southeast quarter of the northwest quarter of section 2 (6 N., 4 W.), and are about a half mile from the B. & B. Railway. The shale deposits run 8 to 20 feet in thickness, and are of a soft blue, clayey nature, very suitable for vitrified wares. To be utilized, they would have to be mined from slope or drift shafts, as the cover above is too heavy to strip. Coal I outcrops 24 inches thick, of good quality, for their burning. A spur from the railway to the exposures could be easily and cheaply constructed.

On the land of J. B. Gibson, near Doans, in section 23 (6 N., 4 W.), are exposures of a blue clayey shale along a small stream. These have proven by digging to be ten or more feet thick, with 3 to 15 feet of cover above. When weathered it forms a tough, plastic clay, which will be found suitable for vitrified wares.

In the southwest quarter of section 16 (6 N., 4 W.), several drifts have been opened on Simon Eisenogle's place. Coal III is here from 30 to 40 inches thick, with a 3-inch clay band near the middle, while below the coal is 10 feet of under-clay of good quality for many kinds of wares.

At the Alvin Philips mine, southwest quarter section 21, coal III is worked by a shaft and by slopes. At the shaft the coal is 16 feet deep. A section at the shaft shows:

Section at Philips Mine.

	<i>Feet.</i>	<i>Inches.</i>
1. Surface clay	8	0
2. Blue to gray shale	8	0
3. Coal III	2	6
4. Shale	0	4
5. Coal III	1	0
6. Under-clay	5+	0

The shale No. 2 and the under-clay could both be worked profitably in connection with the coal as fuel.

In the southwest quarter of section 36 the under-clay below coal III is five feet thick, while at the M. A. Porter bank, in the southeast quarter, it is four feet five inches, with three feet of coal above it.

The above clay deposits were all that my limited time allowed me to visit in Greene County, east of White River. Kaolin, similar to that found in Lawrence and Martin counties, is reported to outcrop on the land of James Sullivan, in Beech Creek Township, southeast of northeast of section 10 (7 N., 3 W.), and on that of W. R. Arthur, near Newark. The extent and thickness of these beds have not as yet been investigated.

The under-clay below coal III, wherever the latter occurs, is the best raw clay material in eastern Greene County. By itself it will not make good paving brick, but can be made into a good quality of sewer pipe and hollow wares. The under-clay of coal I is better suited for stoneware or potters' uses. The shales of this area are of rather poor quality, being for the most part too siliceous to use alone. Combined with either of the above under-clays, they can, however, be made into ordinary, dry-pressed or vitrified brick.

Township 8 North, Ranges 5, 6 and 7 West.

This area comprises 108 square miles, extending from White River westward along the northern boundary of the county, and embracing the civil townships of Eel River, Smith and Wright. Coals III and IV, with their accompanying shale and under-clay deposits, cover the greater part of the eastern two-thirds of this

area, while coal V occurs near the surface in most of Wright Township. The E. & I. and I. & V. Railways run through 8 north, 5 west, and the S. I. through the western third of 8 north, 7 west, the interval being without railway facilities.

West and northwest of Worthington, in 8 north, 5 west, are many outcrops of shales and under-clays. A pottery was operated on a small scale in that town for more than 25 years. The clay was mostly obtained from the land of Mark Hays, three miles west of Worthington. The stratum, occurring beneath an outcrop of coal I, was but two and a half feet in thickness, and required much washing to remove the impurities. A better quality of potters' clay is found on the land of H. S. Shouse, section 12 (8 N., 6 W.), where it occurs in quantity.

At the plant of the Worthington Brick & Tile Co., a mile and a half west of Worthington, a surface clay six feet in thickness is used without stripping for making ordinary building brick and drain tile, the value of the output in 1904 being \$1,700.

Northwest of Worthington coal from two to two and a half feet in thickness has been passed through in digging many wells. Below this is a vein of under-clay three to four and a half feet in thickness, which is suitable for terra cotta and kindred uses. In most places this merges into a fine-grained shaly sandstone.

In the northeast of the southwest of section 7 (8 N., 5 W.), coal IV is worked on the Henry Watts place. The coal runs from 34 to 36 inches, and is a block coal, with clay slips. The roof is gray clay shale, 30 feet thick. Below the coal is three or more feet of under-clay.

In a well on the Darnell farm, in the southwest quarter of section 10 (8 N., 6 W.), 28 feet of blue clay shale, overlain with 14 feet of soil, were noted above coal IV, with three feet of under-clay beneath the coal.

A seam of coal on the land of Mrs. S. J. Fuller, southwest of northwest of section 12 (8 N., 6 W.), was being mined by stripping, the following section being exposed:

Section on Fuller Farm.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil and surface clay.....	4	0
2. Drab clayey shale	4	0
3. Coal IV	2	2
4. Under-clay	3+	0

Nos. 2 and 4 are both free from grit and above the average in quality. The location, however, is too distant from transportation to allow them to be of present value.

On the land of Leander Maners, northwest quarter of section 25 (8 N., 6 W.), two and a half miles southwest of Worthington and two miles west of both the I. & V. and the E. & I. Railways, coal IV is mined by a slope shaft. A section at the mouth of the slope showed:

Section on Maner's Land.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil and surface clay.....	4	0
2. Drab to blue clayey shale.....	7	0
3. Coal IV	3	0
4. Under-clay	5+	0

The under-clay is a soft, unctuous material, free from grit, and will burn into vitrified wares of good quality. It underlies a large area to the north and west of the mine and outcrops a quarter of a mile northeast. On the higher land it will probably run up to 15 feet or more in thickness. The under-clay is a dark gray siliceous material, with an occasional scale of mica visible. It will probably run too high in silica to make sewer pipe or hollow block, but when mixed with the overlying shale can be used for such products. It would, from appearance, burn into fire-brick, flue linings and other refractory wares. The coal mined at this point is a good block coal, suitable for burning all kinds of clay wares.

One-sixth mile southwest of Maners' bank, in the southwest quarter of 25, is the slope shaft of R. H. Talley, where the same stratum of coal is mined. Here the shale deposit above the coal is ten feet thick and the under-clay five or more feet in thickness, the latter being more plastic and less siliceous than at the Maners bank. A spur from the I. & V. or E. & I. railways could be readily put into either of these deposits, and all the facilities for a good clay industry would then be present.

On the W. J. Bonham farm, in the northeast of the southeast of 16 (8 N., 7 W.), Wright Township, coal V, two and a half feet in thickness, has beneath it six or more feet of a good quality of under-clay. Along a branch in the south half of 18 (8 N., 7 W.), coal V and its underlying clay outcrops in a number of places. On the Louis Critchfield farm, in the southeast of the southeast

of the section, the coal is about six feet thick and has nearly ten feet of under-clay below it. The under-clay at both of the above localities can be made into many kinds of clay wares.

At the Uffelman shaft, in the northwest quarter of section 25 (8 N., 7 W.), the following strata are exposed:

Section at Uffelman Shaft.

	<i>Feet.</i>	<i>Inches.</i>	<i>Feet.</i>	<i>Inches.</i>
1. Soft blue clayey shale.....	18	0	18	0
2. Coal IV	2	6	20	6
3. Sandstone	14	0	34	6
4. Drab or blue clay shale.....	10	0	44	6
5. Black shale	9	0	53	6
6. Coal III	3	0	56	6
7. Under-clay	1	6	58	0

Of the section, Nos. 1, 4 and 7, aggregating 29 feet, are suitable for vitrified products.

Township 7 North, Ranges 5, 6 and 7 West.

In this area of 108 square miles are situated the cities of Bloomfield, Switz City and Linton, and some of the largest and most productive bituminous coal mines of the State. All the coals from I to VI are represented, but for the most part the shales and under-clays accompanying them seem not so suitable for manufacturing as in some of the counties to the northward.

Township 7 north, 5 west, is divided by White River into nearly equal halves. East of the river and north of Bloomfield occurs coal III, in the upper part of the ridges. The under-clay below it is of excellent quality for many products, being of the same character as at the Templeton bank, east of Bloomfield. At the old Iron's mine, in the northwest quarter of 25 (7 N., 5 W.), coal I, two feet thick, is directly overlain with two feet of blue and ten feet of drab to yellow shale of workable quality. The under-clay of the coal, as elsewhere below the same vein, when properly washed, can be made into a good grade of stoneware.

West of the river, in sections 4 and 5, there is quite an area of high land, underlain with coal III. On the Virgil Crance farm, in the northeast of the northwest of section 4, this coal was formerly mined to some extent. A section of the old shaft on the slope of a ravine shows:

Section on Crance Farm.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil and yellow clay'.....	5	0
2. Black bituminous sheety shale.....	3	6
3. Coal III	2	10
4. Under-clay	5+	0

The point of outcrop is three and a half miles south of Worthington and three-quarters of a mile east of the E. & I. Railway. The under-clay is of a light gray hue, and contains traces of fossil plant remains. An analysis of a sample of it was made for this report by Dr. Noyes, and its chemical composition found to be as follows:

Analysis of Under-clay Beneath Coal III, on Crance Land, South of Worthington.

Silica (SiO_2)	73.82
Titanium oxide (TiO_2) .....	.60
Alumina (Al_2O_3)	14.46
Combined water (H_2O).....	3.82
<hr/>	
Clay base and sand.....	92.70
Ferric oxide (Fe_2O_3).....	.83
Ferrous oxide (FeO).....	1.95
Calcium oxide (CaO}) .....	.30
Magnesium oxide (MgO).....	.58
Potash (K_2O)	2.07
Soda (Na_2O}) .....	.30
<hr/>	
Fluxes	6.03
Carbon dioxide (CO_2).....	.94
<hr/>	
Total	99.67

The analysis of the Crance clay shows a refractory under-clay, suitable for sewer pipe, terra cotta, flue linings, etc. Its composition is very similar to that of an under-clay used in a large sewer pipe factory at Walker's Station, Ohio, which showed the presence of:

Clay base and sand.....	92.54
Fluxes	6.94

The Crance deposit is at present inaccessible, but the analysis may be taken as showing a close approximation to the average composition of the under-clay beneath coal III, in eastern Greene County.

At Switz City, the junction of the I. & V., B. & B. and I. C.

Railways, there is found, about three feet below the surface, a thick stratum of tough, blue drift clay, which makes a most excellent drain tile. A factory for their production has been in operation for 15 years. At the pit just north of the plant the blue clay has been excavated to a depth of 12 feet, and the deeper the clay the better the tile. Below the blue clay, at a depth of 14 feet from the surface, there occurs a thick stratum of soft blue, clayey shale. Samples of this have been mixed with the overlying clay. The resulting tile were tougher, of a better color, and easier burned than those made of the upper stratum alone.

A bore sunk for coal in the edge of Switz City showed:

Section of Bore at Switz City.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil and clay	4	
2. Drab sandy shale	8	2
3. Soft dark clayey shale.....	8	4
4. Coal IV	3	1
5. Under-clay	5	6
6. Dark sandstone	8	
7. Blue clay shale	13	8
8. Coal III?		4
9. Dark gray under-clay	7	5
10. Blue shale	6	8
11. Coal		6
12. Under-clay		10
13. Gray clay shale	10	6
14. Blue clay shale	8	6

Of a total of 85½ feet we have here 69 feet of clay working materials, which can be made into many different products. Combined with them we have three feet of block coal IV, one of the best clay burning fuels in the State. Three railways are already at hand, and a fourth being built. With this combination Switz City offers especial attractions for clay working industries.

Two miles east of Switz City, in the southeast quarter section 13 (7 N., 5 W.), is the mine of John W. Bennet. A section at the slope shaft shows:

Section at Bennett Mine.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil and yellow clay.....	3	6
2. Gray sandy shale	7	6
3. Soft blue clayey shale.....	10	0
4. Coal III	2	10
5. Under-clay	6	0

The upper shale, No. 2, is too sandy to work by itself, but can be mixed with No. 3 for many products. The latter is a soft, gritless material, suitable for hollow vitrified wares. The coal is a semi-block of good quality, while the under-clay is quite similar to that at the Templeton mine, east of Bloomfield. These shales, with the underlying coal at a depth of between 20 and 25 feet, will be found over a tract of several hundred acres in this vicinity. This tract lies just west of and adjacent to the lowlands of White River. The Bennett mine is about midway between and one and a half miles distant from the I. & V. and E. & I. Railways.

A blue shale lies close to the surface over a large portion of township 7 north, 6 west. In a well on the William Parish farm, in section 7, it is 18 feet thick, with 24 feet of yellow clay and sandstone above; in another well on the J. D. Spencer farm, in the northeast of 15, it was 37 feet thick, with 9 feet of cover; while in a third well on the W. H. Robertson land, northeast of southeast of 16, it was 25 feet thick, and overlain with 10 feet of soil and clay. Below the shale is usually a thin vein of coal, with a stratum of under-clay, four to six feet in thickness, beneath. This under-clay is free from visible impurities, and while not of high refractory grade, it will make excellent sewer pipe or terra cotta.

Linton, a city of 6,000 population, situated in township 7 north, 7 west, near the western border of Greene County, is one of the more important mining centers of Indiana. The coal veins found near there range from four to six feet in workable thickness, and the output ranks in quality among the best bituminous. The shales overlying the coal seams in the vicinity of Linton are, for the most part, too far beneath the surface to allow them to be obtained by stripping. As a consequence no use has heretofore been made of them.

The following section of the shaft of the South Linton Coal Company, located in the northwest quarter of section 26 (7 N., 7 W.), may be taken as representing the average sequence of the strata through the worked seam of coal IV in the region about Linton:

Section of South Linton Shaft.

	<i>Feet.</i>	<i>Inches.</i>	<i>Feet.</i>	<i>Inches.</i>
1. Surface and yellow clay.....	10	0	10	0
2. Gray sandy shale	12	0	22	0
3. Gray clayey shale merging into black shale	23	0	45	0
4. Coal IVb	0	8	45	8
5. Under-clay	3	0	48	8
6. Sandstone	20	0	68	8
7. Blue clayey shale.....	9	0	76	8
8. Dark blue clayey shale.....	17	0	94	8
9. Coal IV	5	0	99	8
10. Hard gray sandy under-clay.....	0	0	99	8

Of these No. 2 is too siliceous for use. Under-clay No. 5 is of good quality, but the seam of coal above is too thin for working in connection with it. The clay will, therefore, probably never be utilized.

The shales (Nos. 7 and 8) comprise 26 feet of material in every way suitable for manufacturing purposes. No. 7 is a soft, unctuous, fine-grained deposit, resembling many of the under-clays in general appearance. It is free from sulphur and iron concretions and is the more valuable of the two. Having above it a good sandstone roof and below it a bottom of shale, it could be readily and easily mined, if occasion should arise to take it out by itself.

No. 8 is darker, harder and more compact. It forms the roof of the worked seam of coal, and, where exposed to air in the entries, it has, like all shales, a tendency to crumble and fall. Much of it, therefore, must, in the older mines, be handled, and either stored in worked-out areas or raised and thrown on the dump. This being the case, and the fuel and railway facilities both being present, a factory at Linton for making these shales into vitrified products would, without doubt, prove a paying investment. An analysis of a specimen of No. 8 shale, taken from the dump at the shaft No. 1 of the Island Coal Company, showed the following composition:

Analysis of No. 8 Shale from Mine No. 1 of Island Coal Co.

Silica (SiO ₂)	55.31
Titanium oxide (TiO ₂).....	1.15
Alumina (Al ₂ O ₃)	22.46
Combined water (H ₂ O).....	7.48

Clay base and sand	86.40
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Ferric oxide (Fe_2O_3).....	7.18
Ferrous oxide (FeO).....	.23
Lime (CaO)66
Magnesia (MgO)93
Potash (K_2O)	2.05
Soda (Na_2O)	2.06
<hr/>	
Fluxes	13.11
Carbon dioxide (CO_2).....	1.24
<hr/>	
Total	100.75

This shows a close approximation to the standard average composition of shales used for vitrified products, and proves the chemical fitness of the shale overlying coal IV for such products.

The under-clay (No. 10) below the worked seam of coal is, in most places, very thin, and soon merges into a hard, compact sandrock. At the South Linton mine the coal lies directly upon the sandstone, which is so hard that the miners have much difficulty in sinking their sumps and the holes for the placing of the roof props.

Township 6 North, Ranges 5, 6 and 7 West.

This area comprises 108 square miles along the southern border of Greene County, being included in the western half of Taylor and all of Washington and Stafford townships. But little coal is found in 5 and 6 west, a large portion of their area either being overlain with Mansfield sandstone or comprising the annually overflowed bottom land of White River.

Wherever coal I occurs in 6 north, 5 west, it overlies three to five feet of a soft, light gray under-clay. In places where the coal has been eroded or removed and the under-clay left it has been weathered to a potters' clay, suitable for stoneware and hollow products. Thus the under-clay is known to occur four feet thick in the northeast of the southeast of section 1, in the northwest of 2, in the northwest of 11, in the southwest of 13 and in the northeast of 22.

Coal III, with its characteristic under-clay, occurs in sections 19, 20, 21, 28, 29, 30, 31 and 32, in the southwestern corner of 6 north, 5 west. One mile northeast of Newberry, in the southeast corner of 19, close to the E. & I. Railway, the following section is exposed:

Section Northeast of Newberry.

	<i>Feet.</i>	<i>Inches.</i>
1. Yellow shale	6	0
2. Coal III	1	0
3. Gray sandy under-clay	3	0
4. Black shale	17	0
5. Ferruginous sandstone	2	0
6. Shelly sandstone	1	6
7. Gray and black shale.....	24	0

Nos. 1, 3 and part of 7 can be utilized for clay products. Just south of the railroad, on the central north and south line of section 30, 40 feet of yellow and gray shale show above the railway grade and 15 feet of black shale below.

At the Woodhouse shaft, in the southwest of the northeast of 30, five feet of yellow and 22 feet of dark blue clayey shale overlie coal III, here two feet four inches thick, with under-clay beneath. This is two-thirds of a mile southeast of the railway.

The main part of 6 north, 6 west, is marsh land or overflowed river bottoms. In the suburbs of Lyons, in the northeast of the northwest of section 4, a shaft 105 feet deep was sunk to coal I. The coal proved to be but two feet three inches thick, but had six feet of under-clay beneath, which, from practical tests, would make a good fire brick.

Mr. W. H. Mayhead, of Lyons, sent in a large sample of pinkish to gray fine-grained gritless clay, taken from a well a mile and a half south of Lyons and about a half mile east from the I. & V. Railway. He states that the bed of clay is 15 feet in thickness, with seven or eight feet of soil and surface clay above. It resembles very closely a plastic clay of similar character found near Freedom, Owen County,* which has been used extensively for terra cotta and encaustic tile. It is a high-grade clay, which, with less cover, could be made available for many products.

At Bushrod, a station on the I. & V. Railway, in the west half of section 8, is a brick and tile factory, operated by C. W. Baughn. The pit from which he secures his clay shows the following strata:

Section of Clay Pit at Bushrod.

	<i>Feet.</i>
1. Black mucky soil	1
2. Blue alluvial clay	13
3. Light gray marly clay.....	10+

*See p. 221.

In the making of tile, about four feet of a mixture of Nos. 1 and 2 are used, the mixture burning to a cherry red hue and forming a close-grained, strong-bodied tile. The blue alluvial clay contains particles of iron oxide mixed with it, but not in sufficient quantity to be harmful.

Stratum No. 3 burns into a cream-colored product of high grade. The raw clay probably contains 20 to 30 per cent. of carbonate of lime. It will make a durable building brick, and, mixed with one-fourth its bulk of sawdust and then burned, will make terra cotta lumber for wall and partition purposes. There is a large demand for this kind of clay ware, and factories are in operation in Indiana only in Newton and Lake counties.* The deposits of clays mentioned are known to cover an area of several square miles in the immediate vicinity of Bushrod.

In Stafford Township (6 N., 7 W.), but little coal has been mined, and therefore not much is known of the underlying clays. At the Combs shaft, in the northwest of the northwest of section 1, from 15 to 17 feet of soft blue shale occurs beneath 10 feet of soil and yellow clay. Below the shale is coal IV, four and a half to six feet thick. The under-clay below the coal is of little value, but the overlying shale could be burned into many kinds of wares.

On the Hunter Bros. farm, three-fourths of a mile west of Marco, a station on the I. & V. Railway, northwest of northeast of 26, a shaft recently sunk to coal showed the following strata above the second thin vein of coal encountered:

Section on Land of Hunter Bros., near Marco.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil and surface clay.....	14	0
2. Yellow sandstone	5	0
3. Gray clay shale.....	13	0
4. Gray sandy shale.....	5	10
5. Coal	0	6
6. Light gray sandstone	17	0
7. Gray clay shale	8	0
8. Gray sandy shale.....	5	0
9. Black sheety shale	4	6
10. Coal V	1	4
11. Soft light gray under-clay.....	5	0

*For an account of the making of this ware see subsequent pages under Clays of Newton and Lake counties.

The shales Nos. 3 and 7 and the under-clay No. 11 are good clay-making materials. The under-clay is one of the best in this section of the State, and can be made into terra cotta, hollow brick, roofing tile, encaustic tile and many high-grade clay products. Coal IV, worked at a depth of 85 feet, is three feet one inch in thickness.

With the exception of three or four small brick and tile factories, which use surface clays only, the clay-working industry has been wholly neglected in Greene County. From what has been written, it will be seen that all parts of the county contain deposits of under-clay of good quality and thickness, and usually overlain with coals sufficient for their burning. In many places deposits of shale which are of workable value also occur above the coal. Transportation facilities are excellent. It would seem, therefore, that persons seeking investment for capital could find within the county a number of sites for large clay industries, which would, under proper management, prove successful from the start.

SULLIVAN COUNTY.

Lying on the western border and south of the center of the State is Sullivan, a county whose mining interests have, in recent years, become of great importance. It is bounded on the north by Vigo County, on the west by the Wabash River, on the south by Knox and on the east by Greene and Clay counties. In shape it is rectangular, with an irregular western border, due to the meanderings of the Wabash. Its length from north to south is 24 miles, and its average width about 18 miles, its area comprising 443 square miles.

But one geological epoch, the Coal Measures of the Carboniferous Period, is represented in the rocks forming the surface of the county. These Coal Measures are everywhere, except along the streams, covered with drift or loess to a depth of 10 to 50 or more feet. The eastern part of the county is broken, and the soil, except the low grounds near streams, is comparatively poor. The western two-thirds is for the most part level prairie, or river terrace, and possesses a much richer soil. The western half of the county, except to the south, drains directly to the Wabash by Prairie, Turman's and Turtle creeks. Busseron Creek, which

flows southwest diagonally across the county, drains the remainder, except a small area in the southeastern corner, part of which drains to White River and part to the Wabash by way of Maria Creek.

The railway facilities are good in the eastern portion, but are lacking in the northwestern third. The E. & T. H. runs north and south through the county a little east of the center. The Effingham-Switz City Division of the Illinois Central crosses from east to west near the center, while spurs from the Southern Indiana, the Monon, the I. & V. and the E. & T. H. permeate all portions of the coal-bearing area east and northeast of Sullivan.

Three coal veins, viz., VII, VI and V, of workable thickness, are mined at many points in the eastern half of the county. The main line of the E. & T. H. Railway marks, approximately, the western limit of mining operations, as west of that railway the thicker veins of coal are found at too great a depth to allow of profitable working. The principal exposures of shales and under-clays are, therefore, east and northeast of Sullivan, the county seat, which is located in almost the geographical center of the county.

Township 9 North, Ranges 8, 9 and 10 West.

Over the eastern half of this area of 108 square miles coals VII, VI and V form the surface, coal VII, with its overlying shales, occurring in the eastern half of Curry Township (9 N., 9 W.), and the western third of Jackson (9 N., 8 W.), while VI and V cover only the eastern two-thirds of Jackson, their area being about equal. The roof of coal VII is either a shale or a sandstone. When the former it is usually a good workable material. The floor of VII in this area is in general an under-clay six to seven feet in thickness, with limestone below. The roof of coal VI is usually a blue, clayey shale of good quality, which runs, normally, 10 to 15 feet in thickness.

At the water station, where the Southern Indiana Railway crosses a branch of Busseron Creek, one mile south of Lewis, in the extreme northeastern corner of Sullivan County, southeast quarter section 1 (9 N., 8 W.), there is an eight-foot exposure of drab to blue clayey shale, evidently that overlying coal VI.

Above the shale is five to seven feet of yellow surface clay. A mixture of the clay and shale can be used in the making of paving brick, sewer pipe and other vitrified products. The shale outcrops in several other places, both above and below the railway bridge, its bottom being hidden, so that its total thickness could not be determined. It evidently lies close to the surface over a large area. Two veins of coal of workable thickness occur below the shale, while water is abundant in the large pond which supplies the railway tanks. With all necessary factors present, clay products can be made at prices that will defy competition.

At the Ziener shaft, in the southwest quarter of section 27 (9 N., 8 W.), 31 feet of soft, clayey shale occur beneath five to seven feet of surface clay, with coal V, six feet thick, below. This is on a spur of the E. & T. H. Railway.

At the Hymera mine, in the southwest of northeast of 33, 12 feet of blue clay shale directly overlies the worked vein of coal VI, here five to eight feet thick. No use has been made of the shale.

In 9 north, 9 west, but few deposits of workable shale seem to occur. At the Berlin shaft, in the southwest quarter of section 1, sandstones for the most part replace the shales above coal VII, and between VII and VI. At Shelburn, in the southeast of 34 (9 N., 8 W.), a clay shale, 11 feet in thickness, overlies the top or rider vein, coal VIII, found at 52 feet, while between that and coal VII, at 175 feet, are 70 feet of clay shales and under-clays of good, workable quality, besides 35 feet of compact siliceous clay shale of doubtful utility. The stratum of clay shale just over coal VII is 16 feet thick, the coal itself averaging four feet in thickness. These shales would have to be mined, and will, therefore, probably never be used.

Township 8 North, Ranges 8 and 9 West.

In this area of 72 square miles are a number of the larger coal mines of Sullivan County. Coals VII to V, with their accompanying shales and under-clays, occur near the surface, coal VI being the principal vein worked. The overlying shale and the under-clay of coal VII are the best clay working materials of the area.

At the shaft of the Star City mine, near the center of section 6, the following strata occur:

Section of Shaft of Star City Mine.

	<i>Fect.</i>	<i>Inches.</i>	<i>Fect.</i>	<i>Inches.</i>
1. Surface and drift	15	0	15	0
2. Shaly sandstone or shale overlying sandstone	45	0	60	0
3. Blue clayey shale	20	0	80	0
4. Coal VII	4 to 4	6	84	6
5. Under-clay	6	0	90	6
6. Limestone	3	0	93	6
7. Gray to blue shale.....	18 to 20	0	113	6
8. Coal VI.....	4 ft. 6 in. to 6	0	119	6
9. Shale	10	0	129	6

Of these Nos. 3, 5, 7 and 9, aggregating 56 feet, could mostly be used for different kinds of clay wares, though No. 9 is of doubtful workable utility.

At the old "Jumbo" or No. 1 mine of the Jackson Hill Coal Company (now worked out and abandoned), located in the south half of section 10 (8 N., 8 W.), coal VI was worked, the upper vein, coal VII, not being present where the shaft was sunk. The only commercial clay at the mine was an unctuous blue shale, remarkably free from grit and fine in texture, which overlay coal VI for a thickness of 14 feet. Above it was eight feet of sandstone and five feet of surface soil. Coal VI, here five and a half feet thick, rests upon a blue shale instead of an under-clay. The same conditions exist at the Star City mine, above mentioned.

At the shaft of the No. 2 Jackson Hill mine, located three-quarters of a mile northwest of No. 1, in southwest quarter section 9 (8 N., 8 W.), the dark brown shale between the coal and overlying sandstone was 12 feet in thickness, the under-clay below the coal being very hard, and also 12 feet thick. The No. VI coal, here worked, is found at a depth of 104 feet, and is five feet six inches thick. In the manway of the air shaft No. VII coal, three feet eight inches thick, was found at a depth of 36 feet below the surface. Just above it was 12 feet of workable shale.

In general it may be stated of this region that wherever the upper or No. VII seam of coal exists it is overtopped with 12 or more feet of shale and underlain with from six to nine feet of under-clay, both of which are suitable for vitrified products. Be-

tween the two veins of coal, and overlying the dark shale or sandstone which forms the roof of the lower or No. VI vein, is often, also, from 15 to 25 feet of an excellent clay shale.

At Cole's mine, in the southwest quarter of section 11, a stratum of "fine fire clay," 18 feet thick, is said to underlie coal VI. On the Ellis place, in the northeast quarter of section 29, coal VII is overlain with six to eight feet of soft bluish gray clay shale and underlain with five feet of under-clay, both of good, workable quality.

At Farnsworth, northwest of northeast of section 32 (8 N., 8 W.), is located the large mine of the Washington Fuel Company, of Chicago. This mine was opened in 1880, and the first year or two only the top vein of coal No. VII was worked; but here, as elsewhere, its quality is inferior to that of the lower No. VI vein, and only the latter is now mined. The shaft is located on the Illinois Central Railway, and a section through it to the bottom of coal VI is as follows:

Section of Shaft at Farnsworth Mine.

	<i>Feet.</i>	<i>Inches.</i>	<i>Feet.</i>	<i>Inches.</i>
1. Soil and drift clay.....	12	0	12	0
2. Gray sandy shale	17	0	29	0
3. Blue clayey shale	8	0	37	0
4. Coal VII	3	4	40	4
5. Under-clay	8	0	48	4
6. Bastard grayish limestone.....	2	6	50	2
7. Blue clayey shale, with occasional nodules of iron carbonate	18	0	68	2
8. Dark bituminous shale, fissile	3	0	71	2
9. Coal VI	5	6	76	8
10. Under-clay, soon merging into gray sandy shale	??			

The top shale, No. 2, contains too high a percentage of silica to work alone. On the other hand, shale No. 7 is of excellent quality, being a fine-grained, gritless material. All of under-clay No. 5 and 15 feet of No. 7 shale can be utilized for paving brick, sewer pipe, hollow brick and other vitrified wares.

Two miles farther east, on the land of Mrs. Thompson, northeast quarter of the northeast quarter of section 34 (8 N., 8 W.), a mine has been opened to supply the local trade with coal. The shaft, sunk only through the upper vein, disclosed the following strata:

Section at Thompson Gin Shaft.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil and yellow clay.....	4	0
2. Shaley "pepper and salt" sandstone.....	8	0
3. Blue clayey shale	16	0
4. Coal VII	3	4
5. Under-clay	5	0

Samples of the shale and under-clay show them to be in every way suitable for vitrified products. This mine is seven miles east of Sullivan and three-fourths of a mile north of the Illinois Central Railway.

At the mine of W. H. Sexton, one-half mile east of the Sullivan Court House, coal VII, 111 feet below the surface, is underlain by six feet of a superior grade of dark gray plastic under-clay; above the coal is 24 to 27 feet of blue, clayey shale, also of workable quality. The lower coal, No. VI, five feet thick, is being mined, and no use is being made of the shales or under-clays, which could be burned into many kinds of clay wares. Three railways are within a quarter of a mile of the shaft.

One and a half miles east of Sullivan, near the foot of the bluff bordering the bottoms of Busseron Creek, on the land of Lewis Eaton, north half of the southeast quarter of section 36 (8 N., 9 W.), a shaft was put down through the top vein of coal, which at this point is about 25 feet below the surface. The following section was secured of the strata exposed in the shaft:

Section at Eaton or Winterbottom Shaft.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil and drift clay	6	0
2. Blue clay shale	17	0
3. Dark bituminous shale	2	0
4. Coal VII	3	2
5. Under-clay	?	0

Shale No. 2 is a hard, compact, fine-grained material, which weathers freely on the dump into a plastic mass, valuable for many products. No samples of the under-clay underlying the coal were obtainable, but it is doubtless of good quality, and similar to that underlying the same coal further east. This mine is one-fourth of a mile south of the Illinois Central and one and a half miles east of the E. & T. H. railways.

The old Watson, Little & Co. mine, east of Sullivan, now

operated by the Rainbow Coal & Mining Co., of Chicago, is located by the side of the main line of the Illinois Central Railway. Both veins of coal have here been worked, but the upper one, No. VII, has been abandoned, as the output from it, when allowed to stand any length of time, air-slacks too rapidly to be of value. If used immediately after being mined, however, it is an excellent fuel. The upper vein is 49 feet below the surface and the lower one 93 feet. An air shaft was being sunk at the time of my visit, and the material from it gave excellent opportunities for examining the character of the strata above the first vein. Of them the following section was obtained:

Partial Section at the Air Shaft of the Rainbow Coal and Mining Co.

	<i>Feet.</i>
1. Surface soil and clay.....	8
2. Gray clay shale	23
3. Blue clay shale, containing remains of fossil plants.....	16
4. Bituminous shale, fissile	2
5. Coal VII	4
6. Under-clay, dark plastic	6

Of these, all of shale No. 2 and the upper half of No. 3, comprising 31 feet in vertical thickness, are suitable in the highest degree for vitrified brick and similar wares. The under-clay will make a good grade of terra cotta, hollow brick and conduits, and may be mixed with the overlying shales for other vitrified products, but it evidently contains too high a percentage of the fluxes for refractory purposes. The three things necessary for the production of clay products, viz., raw material, fuel and transportation, are here present in one spot. Where so combined the finished products may be made at prices that will defy competition. Moreover, if a plant should be located here, the top vein of coal would supply an excellent fuel, as it could be mined only as needed; thus preventing the air-slacking for which it is now condemned.

For a number of years a mine was worked at Sullivan, the shaft being located about 200 yards north of the E. & T. H. station. Owing to litigation, it was abandoned about 1891. The vein worked was coal VI, about 255 feet below the surface. From a ten-foot vein of clay underlying coal VII, 47 feet above VI, Mr. Pollock made, for a time, vitrified drain tile and paving blocks



Two views of the Dump at the Superior Mine, in Sullivan County, showing Waste Shale which has to be Removed from the Entries.

for sidewalks. His plant was located near the coal shaft, and was abandoned soon after work ceased at the mine. The machinery, engine, pug mill, etc., as well as one down-draft kiln and 200 feet of shed room, were still in position a few years ago.

Township 7 North, Ranges 8 and 9 West.

Over this area of 72 square miles, lying south and southeast of Sullivan, coals VIII and VII form the surface veins. Only the latter is of workable thickness. Coals VI, V and IV are of better grade and thickness and are worked by deep shafts at a number of places. The outcropping strata are few and data regarding the clays therefore meagre.

At the Superior Mine, on a spur of the I. & V. Railway, in the north half of the southeast quarter of section 10 (7 N., 8 W.), coal IV, five feet six inches thick, is being mined at a depth of 265 feet. Below the coal is 20 inches of a dark gray, very plastic under-clay, while overlying the coal is 16 to 30 feet of a rather hard, gray to blue clay shale. From three to five feet of this has to be removed from the entries where it falls, and thousands of tons of it are to be seen going to waste in the dump. Here it weathers into a soft and plastic clay, which could be easily burned into many kinds of wares.

Forty-one feet above the worked vein is coal IVa, 18 inches in thickness. It overlies about three feet of a light gray under-clay, which weathers into a potters' clay, suitable for the better grades of stoneware.

Coal V, 4 feet 10 inches thick, is found 137 feet above IV, while VI, formerly worked, is 55 feet above V. The last-named has but 18 or 20 inches of under-clay beneath it. Between VI and V is a thin, four-inch vein, which overlies four feet of good, workable under-clay. A 16-foot stratum of workable shale also lies between coals VI and V. Here we have three thick veins of coal, a plentiful supply of clay-working materials and a railway already built. The company owns 853 acres in fee simple about the mine, and has an additional large area under lease.

Coal VII, with overlying shale, outcrops at a number of points in the western half of 7 N., 8 W., but no data is at hand regarding the accompanying clays.

A boring near Paxton, a station on the E. & T. H. Railway, in sections 26 and 27 (7 N., 9 W.), showed 10 feet of blue clay shale immediately below 14 feet of surface clay. Coal VII, three and a half feet thick, was struck at 156 feet. Below it was five feet of good, workable under-clay. Coal VI, at 207 feet, was six feet thick, with 17 feet of gray clay shale above.

Township 6 North, Ranges 8 and 9 West.

Over this area of 72 square miles, in the southeast corner of Sullivan County, coals VIII and VII, with their accompanying strata, form the greater part of the surface. Coals VI and V outcrop in the eastern third of 6 N., 8 W. With the exception of the E. & T. H., passing north and south through the center of 6 N., 9 W., railway facilities are lacking.

At the George Ward gin shaft, a quarter of a mile southeast of Pleasantville, southeast quarter of section 12 (6 N., 8 W.), coal VI, 4 feet 10 inches thick, is mined at a depth of 38 feet. Just above the coal is found 13 to 17 feet of gray clay shale, while a good, workable grade of under-clay, seven or more feet in thickness, is found below. The upper three feet of this clay is dark and plastic, the lower four feet being lighter and more like "soap-stone." The coal will be found of excellent quality for burning clay wares.

By the roadside on the Hume hill leading down to Maria Creek, in the southwest quarter of section 9, about four miles west of Pleasantville, are several exposures of a light gray, very plastic potters' clay, which, for a long time, was used at Pleasantville in making a better grade of stoneware. The stratum of clay lies immediately beneath a layer of sandstone, has an average thickness of about three feet, and is readily accessible.

On the land of Robert Benefiel, in the southeast quarter of section 9, the same clay outcrops beneath a ledge of limestone near the bottom of a deep ravine.

Carlisle, a growing town of 800 population, on the E. & T. H. Railway, in southern Sullivan County, lies in the center of a region about four miles square, which is abundantly supplied with clay-working materials. The yellow surface loess clay, found in the vicinity of the town, is 12 to 18 feet in thickness, and suit-

able for ordinary or pressed front brick or drain tile. It usually overlies a bed of blue clay shale, 18 to 40 feet thick. Mixed with these shales, the surface clay will make paving brick or other vitrified products.

The under-clay below coal VII, in the vicinity of Carlisle, runs between six and eight feet in thickness, and is a soft, plastic material, which requires the addition of a more siliceous clay for some wares. For some time it was mined and sold for \$1.50 per ton, f. o. b. the cars, to the Uhl Pottery Co. and Decker Bros., of Evansville. The former used it for making stoneware and the latter, when mixed with shale, for paving brick.

Samples of both under-clay and shale from around Carlisle have been burned for Mr. C. A. Ellis, of that town, by a number of parties, all of whom speak highly of the wares produced. From two of the letters sent to Mr. Ellis I quote briefly, the first, under date of October 24, 1902, being from Thomas Proud, the superintendent of the Indiana Paving Brick Co., at Brazil, who wrote, in part, as follows:

"The shale you sent is the best I ever saw. Tested to make paving brick, it burns as hard as iron and is very tough. It will not stand quite as much fire as the shale here. The under-clay will make hollow brick or vitrified drain tile of good quality."

The other, from A. B. Horne, Lancaster, Ohio, written December 22, 1902, spoke of three samples of shale, as follows: "As you will see, the burned pieces of shale are all fine, No. 1 exceedingly so, being excellent in color and fit for almost any kind of clay goods. No. 2, a mixture of Nos. 1 and 3, would make equally as good, if not better, vitrified materials. I am not so sure about No. 3, burned by itself, but have no doubt but that if it were worked on a large scale with No. 2 it would make good vitrified brick."

Coal VI, five feet three inches thick, underlies coal VII, and the above-mentioned clays in the vicinity of Carlisle at a depth of about 245 feet from the surface.

A short distance north of Carlisle, by the side of the E. & T. H. Railway, Mr. J. P. Walls for a long time manufactured, on a small scale, fire and ornamental brick from the vein of under-clay, eight feet thick, which underlies coal VII, at a depth of 200 feet. He informed me that this clay withstands great heat with

but little shrinkage, and the products do not crack in drying or burning. Coal VII at that point is three feet thick and gives good satisfaction as a fuel in burning ordinary brick, of which he made large numbers.

The clays and shales of eastern Sullivan county, lying as they do in close proximity, either above or below thick veins of excellent fuel, should be put to some use other than the making of ordinary brick and drain tile, which are now the only forms of clay products made in the county. Railway facilities are excellent, and with the proper expenditure of capital by men of energy the county could become as noted for its clay industries as it now is for its bituminous coal mines.

KNOX COUNTY.

This county comprises one of the most fertile sections of Southwestern Indiana. The Wabash River forms its western boundary and White River its eastern and southern. The broad valleys of these streams form a large portion of the surface of the county and greatly increase the average richness of its soils. It comprises an area of 540 square miles, and lies south of Sullivan and Greene, east of the Illinois State line, west of Daviess and north of Pike and Gibson counties.

The upper or barren Coal Measures form the surface rocks of the greater part of its area. The lower or productive measures underlie the whole county, but at such a depth as to prevent the remunerative mining of coal, except at a few points along the eastern border, where the principal veins of these measures outcrop in or near the bluffs of White River.

The upper or barren measures are made up, for the most part, of alternating strata of sandstones and shales. At intervals are thin beds of "rash" coals of no economic value. The total thickness of these deposits is more than 300 feet, and above them lie, in most parts of the county, from 10 to 75 feet of drift, alluvium or loess, which hide the more compact rock strata from view. In the valleys these pleistocene deposits run up to 100 feet in thickness, and in some of the old valleys which have not been cleared out, may exceed that. On the uplands the drift and surface will seldom exceed 30 feet, and will generally run between

10 and 20 feet. At Vincennes, the county seat, the first sandstone found in a test bore put down in the city park was found at a depth of 71 feet, and the first vein of coal of workable thickness at a depth of 383 feet.

The divide between White and Wabash rivers extends through the center of the county, the western half being drained into the Wabash by Busseron, Marie and Deshee creeks and their smaller tributaries, while the eastern half drains into the West Fork of White River through Black Water, Indian and Pond creeks. The two forks of White River unite at the southeastern corner of the county.

The railway facilities of the county are fairly good. The B. & O. S. W. crosses from east to west near the center; the E. & T. H. from north to south through the western third. The I. & V. and the Cairo Division of the Big Four cross from northeast to southwest. All converge at Vincennes, the oldest town in the State, which is well situated as regards transportation and is rapidly becoming a manufacturing center of importance.

Townships 4 and 5 North, Range 8 West.

The most important mining area of Knox County is in the northeastern part in the 72 square miles embraced in the townships mentioned. The I. & V. Railway crosses the area from northeast to southwest. Coals VII, VI and V, with their accompanying shales and under-clays, form the surface rocks, but all are more or less covered with drift, loess and sand. In general it may be stated of the area that the under-clay beneath the top vein or coal VII, and the blue shale overlying coal VI are both of excellent grade for manufacturing purposes.

One and a fourth miles north of Edwardsport, northeast quarter of section 36 (5 N., 8 W.), a slope shaft was put into a hill in 1895. This is known as the Hoffman, or Edwardsport Coal and Mining Co.'s mine. Test bores put down in the side of the hill above the shaft show the presence of the following strata:

Section of Hill near Hoffman Mine.

	<i>Feet.</i>	<i>Inches.</i>	<i>Feet.</i>	<i>Inches.</i>
1. Soil and drift clay.....	12	0	12	0
2. Blue sandy shale	10	0	22	0
3. Coal VII	3	2	25	2
4. Under-clay	3	4	28	6
5. Blue clayey shale	39	0	67	6
6. Dark bituminous shale	3	0	70	6
7. Coal VI	5	3	75	9
8. Under-clay	2	0	77	9

The under-clay, No. 4, is a dark gray plastic material of very fine texture and with an occasional trace of *stigmara* or other fossil plant remains. It can be made into terra cotta, hollow building block, conduits, fireproofing of various kinds, vitrified drain tile, etc. The blue shale, No. 5, has the fine texture and unctuous feel characteristic of the better grades of materials suitable for hollow brick, pressed front and paving brick, sewer pipe and kindred products.

Nearer town, in the southeast quarter of section 35, the under-clay at the level of coal VI was found to be nine feet thick. Just south of the I. & V. Railway station an exposure of shale suitable for pressed front brick lies alongside the railroad track. It is six to eight feet in thickness and overlies coal V, which is here exposed to a depth of about three feet.

At the Keith mine, three-fourths of a mile south of Edwardsport, northeast quarter of section 12 (4 N., 8 W.), the under-clay beneath coal V, which is here worked, is about four feet thick, but is much inferior in quality to that found below VII higher up. It is more siliceous than the latter and contains some pyrites, and many *stigmara* and other plant remains. A short distance below this, southeast quarter section 12, coal V outcrops at low water mark in the bed of White River. At this point it is overlain with a black calcareous shale, above which is a dark colored limestone; the two together aggregating about eight feet in thickness and containing numerous fossils, among which are sections of some very large crinoid stems and spines.

At the Brickyard mine, in the northeast corner of section 11 (4 N., 8 W.), coal VI is overlain with 18 feet of sandstone and shale and lies 25 feet above coal V, which is here worked. At the brickyard a yellow loess surface clay seven feet thick, is

used for soft mud brick after stripping four inches of sod and soil. The clay overlies a shale, about eight inches of which is mixed with the loess.

At the Bicknell mine, southeast quarter of section 16 (4 N., 8 W.), the shale found above coals VII and VI, at Edwardsport, is largely replaced by sandstone. Coal VII lies 47 feet, and coal VI 92 feet below the surface. Both are worked, and the under-clays and workable shales pierced by the shaft aggregate 13 feet in vertical thickness.

At the shaft of the Enterprise mine, on the I. & V. Railway, two miles west of Bicknell, coal VII, two feet 10 inches thick, was struck at a depth of 109 feet. It is underlain by four feet of a most excellent grade of light gray, plastic under-clay which can be burned into stoneware, conduits, hollow building block, sewer pipe and many wares of a similar class. Coal VI, four feet six inches thick, is mined at a depth of 156 feet, and is overlain with 11 feet of fine grained, dark gray shale, which weathers into a soft, plastic material, suitable for vitrified products of various kinds.

South of the above area, exposures of shale and under-clay suitable for manufacturing purposes are few. In a bluff of White River, Don. 134 (3 N., 8 W.), 25 feet of clay shale with ironstone nodules are exposed between coals VII and VI, both the latter being of workable thickness. At the Monroe City Coal Company's shaft, in Don. 228 (2 N., 8 W.), 55 feet of blue clay shale was passed through above coal VII, here four feet thick. Overlying the shale was 19 feet of clay and quicksand. At Allen & Foulke's bank in the northeast quarter of 9 (1 N., 8 W.), coal VII, averaging nearly three feet in thickness, is overlain by six feet of good workable clay shale and underlain with four feet of "fire-clay." As all these points are distant from transportation facilities, it is doubtful if they are ever utilized.

Near Oaktown, a station on the E. & T. H. Railway, a bore sunk to a depth of 236 feet in search of coal, disclosed 64 feet in vertical thickness of under-clay and workable shales. One of the strata of under-clay, ten feet six inches in thickness, was found about 120 feet below the surface, immediately below a four inch vein of coal; the latter being overlain with limestone.

This clay was white to dark orange in color and was said by experts to be a good terra cotta material.

The Prospect Hill mine, one and a half miles southeast of the City Hall at Vincennes, was long worked for the local trade. The shaft was sunk in a comparatively low place near the Sugar Loaf Mound. The worked vein of coal, probably No. VII, occurs here at a depth of 355 feet. It is four feet thick and has above it a stratum of fine grained, gray shale, 42 feet in thickness. This forms an excellent roof, being massive instead of in laminæ, and when blasted breaking with a conchoidal fracture. An analysis of this shale by Dr. Noyes shows its composition to be as follows:

Analysis of Shale from above Coal at Prospect Hill Mine.

Silica (SiO_2)	64.05
Titanium oxide (TiO_2).....	1.00
Alumina (Al_2O_3)	16.00
Water combined (H_2O).....	3.79
<hr/>	
Clay base and sand.....	84.84
Ferric oxide (Fe_2O_3).....	.89
Ferrous oxide (FeO).....	5.85
Lime (CaO}) .....	.42
Magnesia (MgO)	2.00
Potash (K_2O)	2.59
Soda (Na_2O)	1.19
<hr/>	
Fluxes	12.94
Carbon dioxide (CO_2).....	2.68
<hr/>	
Total	100.46

Comparing this with the standard composition of clays suitable for vitrified products, see page 82, we find it varying but slightly, and that toward a greater purity. Practical tests in the kiln would probably prove what the chemical composition intimates, and show conclusively the fitness of this shale for paving brick, sewer pipe and kindred products.

The under-clay beneath the worked coal at the Prospect Hill mine has been pierced to a depth of ten feet without reaching bottom. It is a dark gray, plastic material, of exceedingly fine texture, and with an occasional trace of stigmaria. A partial analysis of a sample of clay from the same stratum taken from

the mine of the Vincennes Coal Company, one-half mile north-east, was made a number of years ago by Dr. J. N. Hurty, who determined the percentage composition of the following constituents:

Partial Analysis of Under-clay from Beneath Worked Vein of Coal near Vincennes.

Silica (SiO_2)	65.315
Alumina (Al_2O_3)	28.473
<hr/>	
Clay base and sand.....	93.788
Lime (CaO}) .....	.179
Magnesia (MgO)	2.741
Ferric oxide (Fe_2O_3).....	3.120
<hr/>	
Fluxes	6.040
Moisture .....	.170

"This clay burns to a yellowish white and will make an excellent fire-brick."

The under-clay from the Prospect Hill mine can also be made into terra cotta, sewer pipe and fireproofing for walls and chimneys. Two feet of the clay has to be blasted out in all the entries for height. Most of this is stored in worked out areas, but hundreds of tons of it and the shale above the coal are raised to the dump, where they soon weather into a fine plastic mass.

The location of a large clay industry at either the Prospect Hill mine near Vincennes, the old Hoffman mine just north of Edwardsport, or the Enterprise mine west of Bicknell, can not but prove a paying venture. At all three places raw material in abundance and of excellent quality for many products is found. At all three fuel for burning this material is plentiful. The Hoffman and Enterprise mines each have a railway switch already completed. One can easily be constructed to the Vincennes mine, and the latter being placed in connection with the four railways entering that city, will then have the better transportation facilities.

The yellow loess clay is utilized for soft mud brick making at three or four points in the suburbs of Vincennes.* From five to ten feet are used after stripping three to four inches of sod and top soil.

*See statistical table near end of paper.

DAVIESS COUNTY.

Lying about half way between the center of the State and its southwestern corner is Daviess, one of the better agricultural counties of southern Indiana. It is situated west of Martin, south of Greene, east of Knox and north of Dubois and Pike counties. The West Fork of White River forms the western and the East Fork the southern boundary of the county, the two uniting at the southwestern corner. The county has an extreme length from north to south of 28 miles and a width of 20 miles; its area comprising 430 square miles.

The Coal Measure rocks form the surface of nearly the entire county, the Mansfield sandstone outcropping along the streams of the northern and eastern edges. The northeastern part of the county is, therefore, quite broken with the characteristic hills and ridges of the conglomerate sandstone which here forms much of the surface rock. Going west, southwest and south, this quickly changes to a rolling country and that in turn to a very level surface; many prairies on the sites of former marshes and lakes being found along Smithers and Prairie creeks and their tributaries. Most of Elmore, Bogard, Steele, Washington and Barr townships are of this level character, with some rolling land. Northeast of Washington is a conspicuous group of hills. The southern part of the county, as White River is approached, again becomes quite hilly.

The drift, as to the north, consists of clays, sands and gravels. These have a thickness of from 0 to 90 feet, the latter depth occurring only where old valleys have been filled up. As a rule, the drift will average less than 20 or 25 feet thick, yet, from the level nature of most of the county, is sufficiently thick to hide nearly all the natural outcrops, due principally to most of the streams following their old courses, though many score of feet above their old beds. It is probable that the surface was formerly nearly, if not quite, 100 feet above the present level.

The northern third of the county is drained into the West Fork of White River by Furse, Indian Pond and Smithers creeks. The central third drains into the same stream through Prairie Creek and its tributaries. From the southern third, Veale Creek flows west into the West Fork, while Aikman's,

Mud, Sugar, Slate and Haw creeks flow either south or east into the East Fork of White River.

Three railways pass entirely through the county; the Southern Indiana and B. & O. S. W. from east to west, the former across the northern third, the latter a little south of the center. The E. & I. Railway runs north and south through the western third.

Washington, the county seat, has long been one of the more important mining centers in the State. It lies almost half way between St. Louis and Cincinnati, and in 1891 secured the shops of the B. & O. S. W. Railway. Since that date, it has almost doubled in size, possessing at the present a population of about 9,500. Coals VII and VI, with their accompanying shales, occur in the county only in the immediate vicinity of Washington, and therefore some of the principal coal mines of the county, as well as the larger deposits of commercial clays which lie close enough to the railway to admit of profitable working are there situated. Many shafts have been sunk and bores put down just east and south of the city. These prove the presence of shale and fire-clay deposits in abundance, though in but few places do they come so near the surface as to admit of being worked by stripping.

Coals V and IV, with their overlying and intervening strata cover three-fourths of the area of the county and have been extensively mined east and southeast of Washington. Coals IIIc, IIIb and III come close to the surface along the eastern edge and in the northern fourth of the county.

Township 5 North, Ranges 5, 6 and Part of 7 West.

In this area of about 75 square miles along the north edge of the county coal V is the highest coal found, and it may be questioned whether it occurs other than in a hill on the western border of the area. Coal I outcrops at the east and its under-clay, wherever found can be burned into stoneware or terra cotta. As far as discoverable, no workable coal exists in the area. Furse and Smithers creeks drain the area and the divides between them are from 75 to 135 feet above the creek, or even higher. The western and much of the southern part of 5 north, 6 west, is

prairie. One or two ridges extend in from the east, but become rapidly reduced in height. The Southern Indiana Railway crosses the area from east to west; while the E. & I. crosses its western end.

The Southern Indiana runs through a shale cut nearly a quarter of a mile in length in the south half of section 25 (5 north, 5 west), about a mile and a quarter northwest of Burns City. The shale is exposed to a depth of 12 feet and has above it eight feet of yellow clay. The shale is a soft, gritless, drab to blue clayey material, and probably overlies coal III. It can be burned into vitrified brick, sewer pipe and hollow block of good quality.

The overlying yellow clay is the fine grained siliceous material known as loess, which occurs over a large area in southwestern Indiana. It is wholly free from pebbles of lime and other impurities and will make a good dry pressed front brick or a high quality of ordinary brick. The loess at this cut can be mixed with the underlying shale in the proportions in which it occurs to make vitrified products, and its stripping can, therefore, be avoided. With cheap fuel in close proximity and a railway already in place, the vicinity of this cut furnishes an excellent site for a clay factory of large size.

On the Turner farm, in the southeast quarter of section 36 (5 N., 6 W.), a bore showed the presence of:

Section on Turner Farm.

	<i>Feet</i>	<i>Inches.</i>
1. Surface soil and loess clay.....	10	0
2. Ferruginous shale	6	0
3. Coal III	1	6
4. Under-clay	2+	0

The surface clay, No. 1, is a good brick making material, while the under-clay is said to be "good for fire brick."

On the land of H. Dillon, two miles southeast of Elnora, in the northwest quarter of section 23 (5 N., 6 W.), occurs a fine deposit of yellow loess clay which is used for making ordinary soft mud brick at Elnora. The deposit is on the west side of and is reached by a short spur from the Southern Indiana Railway. The loess is at this point 10 or more feet thick, and is said to be underlain by a white marly clay. It is very pure in quality and makes a high grade, hard and durable brick. It could also

be made into drain tile of large size, such as are made by the National Drain Tile Company at Summitville, Ind., or into pressed front brick. At the deposit a cut has been made of sufficient depth to allow a flat car to be pushed in beneath a platform bridging the cut. A hole in the center of this platform allows the clay to be scraped with iron scrapers, operated with horses, directly into the car.

Township 4 North, Ranges 5, 6 and 7 West.

This area of 102 square miles is very level at the west, but gradually rises and becomes more broken to the east, the highest point being probably in section 10 (4 N., 5 W.), where, near the center of the section, a hill is about 150 feet above Prairie Creek. On the north the country is more nearly level. Steele Township is very level, mostly prairie, but somewhat broken by sand ridges. The E. & I. Railway covers the western portion, the eastern two-thirds being without railway facilities.

Coal IV is extensively worked for local use about Epsom, in 4 north, 6 west; while at Raglesville, coal III is mined at a number of places, and hauled in wagons to the Southern Indiana Railway.

At the Union Coal Company's bank, near the center of section 11 (4 N., 5 W.), the following section is exposed:

Section at Union Coal Company's Bank.

	<i>Feet.</i>	<i>Inches.</i>
1. Shale	50	0
2. Coal IIIb	1	4
3. Shale, gray	12	0
4. Bone coal		3
5. Coal III	3	3
6. Under-clay	4+	0

A part of No. 1 and all of Nos. 3 and 6 can be burned into vitrified wares. By utilizing No. 3 for clay working purposes, both coals could be mined with profit. Both are said to be of excellent quality, burning to a pure white ash.

At Doan's mine, in the southeast quarter of section 2 (4 N., 6 W.), coal IV, three feet thick, is underlain with 10 feet of fire-clay which is very pure and white, so much so that it is said to

have been used for whitewashing in the neighborhood. It can be burned into stoneware, terra cotta, conduits, etc.

At the J. M. Myers shaft, in the village of Epsom, northeast quarter of section 15 (4 N., 6 W.), coal IV is mined from 15 feet below the surface and overlies four or more feet of the same quality of under-clay.

One mile south of Plainville, near the E. & I. Railway, in the northwest quarter of section 14 (4 N., 7 W.), a bore sunk for coal disclosed the following section:

Section of Bore South of Plainville.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil and loess clay.....	13	0
2. Shale	47	0
3. Coal IV (upper bench).....	1	6
4. Under-clay	2	0
5. Coal IV (lower bench)	2	0
6. Shale with a little limestone.....	15	0
7. Coal III	3	10
8. Under-clay, shale, etc.....	16	0

This shows a plentiful supply of clay-working materials. By utilizing the under-clay between the two benches of coal IV, both could be mined with profit.

Township 3 North, Ranges 5, 6 and 7 West.

In this area of 102 square miles occur coals VII to III, inclusive, with their accompanying shales and under-clays, coals VII and VI being found only in the vicinity of Washington, in 3 north, 7 west. The most of the area is very level or slightly rolling, with many old preglacial channels scattered throughout. Drift deposits completely cover the area, ranging in thickness from 10 to 75 feet. In the eastern part of the area, coal IV overlies a bed of under-clay of good quality and from four to 10 feet in thickness. Between this and coal III, there are usually two or more strata of gray shale and one of under-clay, the latter occurring either beneath a thin vein of coal or a layer of black shale which represents the coal. The under-clay beneath coal III, runs up to five feet in thickness, and where exposed and partly weathered becomes a good grade of potters' clay. Coal I, where drilled to or exposed also overlies a four to six foot bed of good under-clay.

At the Buckeye shaft, at Cannelburg, by the side of the B. & O. S. W. Railway, northwest corner of section 29 (3 N., 5 W.), coal IV, three feet thick, occurs 39 feet below the surface, with five feet of under-clay beneath. Coal IIIa, 16 inches thick, occurs 58 feet from the surface, with seven feet of gray, clayey shale above and one foot of under-clay beneath. Coal III, four and a half feet thick, in two layers—the upper, cannel coal—occurs 74 feet down, and overlies two or more feet of under-clay. The shale and under-clays mentioned are all of good workable quality.

At the shaft of the Mutual Mining Company, half a mile south of Cannelburg, in the southwest quarter of section 29 (3 N., 6 W.), coal IV is overlain by 14 feet of soft blue shale and underlain by five feet of under-clay, both capable of being made into many kinds of clay wares. The under-clay beneath the worked vein of cannel and bituminous coal is hard and shale-like, but could be worked.

Just west of Montgomery, in the northeast quarter of section 27 (3 N., 6 W.), by the side of the B. & O. S. W. Railway, is the large No. 2 mine of the Daviess County Coal Company, a section of the shaft of which shows:

Section of Shaft of Mine west of Montgomery.

	<i>Feet.</i>	<i>Inches.</i>
1. Yellow loess clay	10	0
2. Sandstone	6	0
3. Coal V	1	6
4. Hard flinty under-clay.....	1	3
5. Blue clayey shale	20	0
6. Under-clay	4	0
7. Blue shale	20	0
8. Coal IV	3	6
9. Under-clay	10	0

The blue shales, Nos. 5 and 7, and the under-clays, Nos. 6 and 9, are suitable for many kinds of vitrified clay wares. Large quantities of the clay, No. 9, have to be removed. Although of excellent quality it is not utilized, but is relegated with other refuse to the dump pile. The large expense necessary to mine and raise it is thus wholly lost.

Near the center of section 23, about a mile north of Montgomery, is the Desser slope shaft, where coal IV is mined. A section at the mouth of the slope shows:

Section of Desser Mine, north of Montgomery.

	<i>Feet.</i>	<i>Inches.</i>
1. Drab or brown to yellow sandy shale.....	3+	0
2. Coal IV	3	5
3. Under-clay	5	0
4. Shale		4
5. Coal IIb	1	6

By utilizing the under-clay, No. 3, which is suitable for many kinds of clay wares, coal IIb could also be mined with profit, making a total of about five feet of coal.

Three-quarters of a mile southwest of Montgomery, southeast quarter of section 27 (3 N., 6 W.), near the residence of Mike O'Hefferman, an outcrop of potters' clay, three feet thick, occurs by the roadside. It has been tested and proved of good quality for the making of ordinary stoneware.

The city of Washington, in the south part of 3 north, 7 west, is situated on the low divide separating the principal forks of a small stream which flows westward to White River. It is surrounded on all sides but the west by an irregular chain of hills. These hills are highest to the northeast of town in section 25, where they are about 100 feet above the surrounding level. They are quite low just east of the city, but rise as they cross its southeastern corner and are higher to the south and southwest. To the northwest of Washington there is only a broad elevation. A second hill rises southwest of South Washington, separated from the previously described hills by a low space. This hill runs west to the river, its southern edge being cut down by the tributaries of Veale Creek. The outcrops of coals VII and VI, with their shales and under-clays, occur about the margins of these hills. East and north of the hills about Washington, the country is very level.

The yellow loess surface clay found in the vicinity of Washington, is in quality much above the average of the surface drift clays of the counties to the north. It is almost wholly free from lime or other pebbles, is very fine grained, and the deposits, averaging 15 to 18 feet in thickness, are of uniform character throughout. It can be made into a fine, dry-pressed front brick. The ordinary soft mud brick made from it are harder, tougher and of better quality generally than those made of the drift clays

to the north. Mixed with under-clay or shale in the ratio of one part to three, this clay will add to their value for making many products.

On the land of Mrs. R. Shepherd, two miles north of the city, southeast quarter of section 14 (3 N., 7 W.), a blue clayey shale outcrops along the banks of a small stream. The shale is exposed to a depth of ten feet, and is overlain with five feet of yellow loess clay of excellent quality. The two can be mixed and made into dry pressed brick and many other products.

One-half mile south of the depot of the B. & O. S. W. Railway, at the point where the bridge on the Petersburg road crosses the cut of an old railway switch, is an outcrop of "soapstone" or soft unctuous shale, 20 feet thick. The switch could be easily replaced and the deposit utilized. The clay is of the better quality and suitable for many purposes.

At Cable & Kaufmann's No. 4 mine, southwest quarter of section 3 (2 N., 7 W.), the seam of coal V mined is so thin as to necessitate the removal of several feet of material either above or below, in order to make height for mules and cars. The under-clay beneath the coal is of fine quality for making terra cotta, conduits and similar products. It is of very fine texture, and free from the impurities that many such clays contain. Thousands of tons of it are raised each year, and up to the present the dump pile has been its landing place. The vein is said to be seven feet thick, of which the upper two and a half feet is taken out. Above the coal is a soft gray, clayey shale, which can be mixed to good advantage with the under-clay and the two made into many kinds of vitrified products.

A few rods south of this mine a bore was, about 1893, put down 800 feet in search of coal. At this depth a strong flow of mineral water was obtained which continued unabated until the well was plugged.* A record of this bore for the first 142 feet shows the presence of the following strata:

* For a fuller account of and analysis of this water, see the 20th (1895) Report of this Department, p. 98, or the 27th Report (1901), p. 44.

Section of Bore near No. 4 Mine, south of Washington.

	<i>Feet.</i>	<i>Inches.</i>	<i>Feet.</i>	<i>Inches.</i>
1. Soil and yellow loess.....	13	0	13	0
2. Gray sandy shale	16	0	29	0
3. Coal V	3	6	32	6
4. Under-clay	7	6	40	0
5. Gray clayey shale	12	0	52	0
6. Blue clayey shale	13	0	65	0
7. Gray sandy shale	22	0	87	0
8. Blue clayey shale	36	0	123	0
9. Dark bituminous shale.....	6	0	129	0
10. Coal IVb	1	6	130	6
11. Blue shale	11	6	142	0

Of these, Nos. 4, 5, 6, 8 and 11 are clays suitable for manufacturing purposes. These aggregate 80 feet out of a total of 142 and, taken in connection with the coal and the switch already in place, form a combination hard to excel for a great clay manufacturing site.

One mile east of Washington, on the main line of the B. & O. S. W. Railway, southwest quarter of section 25 (3 N., 7 W.), is a mine controlled by Hyatt Brothers, a section of the shaft of which shows:

Section at Hyatt Bros. Mine, east of Washington.

	<i>Feet.</i>	<i>Inches.</i>
1. Surface and yellow loess clay.....	50	0
2. Dark gray shale	1	6
3. Coal VI	3	4
4. Under-clay	3	6

Samples of the under-clay sent to this office by the owners in 1904 show it to be fine grained plastic clay with traces of stigmata and other plant fossils. It can be used for making terracotta, encaustic tile, hollow building block, conduits and similar products. Much of the clay has to be removed to make height, and its handling necessitates quite an expense. Under such conditions a clay industry could be operated very cheaply.

At the old Wilson shaft, southeast of Washington, in the northwest quarter of section 35, coal VI was found to be overlain with 16 feet of clay shale and underlain with three to five feet of under-clay.

At the Wilson shafts, Nos. 1 and 2, just east of the corporate limits of Washington, coal VI, now largely worked out, is under-

lain with seven feet of fire-clay. Beneath the latter is a gray sandstone five feet in thickness. This overlies a blue clay shale which, according to bores made by Thomas Wilson, one of the former owners of the mine, is 37 feet thick. Mr. Wilson states that the shale closely resembles that used at Clinton and Brazil for the making of vitrified street brick.

Township 2 North, and Part of 1 North, Ranges 5, 6 and 7 West.

On account of its lack of transportation facilities but little information is at hand regarding the clays of this area, which comprises about 145 square miles of the southern third of the county. The only railway entering it is the E. & I., which crosses the western margin. Coals IIIb and III, with accompanying strata, form the surface rocks of the eastern third of 1 and 2 north, 5 west. Coals IV and V occur over the remainder of the area; while VI is found in the northwestern corner of 2 north, 7 west.

At the Patterson bank, in section 11 (2 N., 5 W.), coal III, four feet thick, has 16 to 18 feet of workable shale above and a fair quantity of under-clay beneath.

Just west of Alfordsville, in the southwest quarter of section 34 (2 N., 5 W.), the shaft of the Denson mine showed an aggregate of 27 feet of workable shales and under-clays above the worked vein, coal III, found at a depth of 39 feet.

On the farm of Cross Bros., northeast quarter of section 17 (2 N., 6 W.), a shaft sunk to a depth of 14 feet in search of gold and platinum, showed the following section:

Section of Shaft on Cross Bros. Farm.

	<i>Feet.</i>
1. Soil and surface clay.....	4
2. Dove-colored clayey shale	6
3. Dark bituminous shale.....	4

Shale No. 2 is a soft "soapstone," divided into thin layers or laminæ, between which is a thin incrustation of oxide of iron. This was pointed out to me as a gold bearing material, and the statement was made by Mr. F. M. Cross that it had been assayed and found to contain gold to the amount of \$36 to the ton. It is needless to say that such a statement is absurd. The shale will

make a fair quality of vitrified brick or sewer pipe, but all the gold and platinum contained in forty acres of it would not pay one-twentieth of the amount spent in sinking the shaft.

Within the past ten years more than five millions of vitrified brick and block from Evansville, Indiana, Athens, Ohio, and other points have been shipped to Washington and put down in the streets. These have cost from \$10 to \$14 per thousand. The raw material for making them and the fuel for burning them was to be found in abundance within two miles or less of the spot where they were laid. The sum sent out of the county in payment for this paving material would have paid for a good plant for manufacturing it, which would have furnished labor for many hands.

The B. & O. S. W. and the E. & I. railways, or their switches, pass through or close to many of the leading deposits above mentioned, and connect the city of Washington with numerous towns in Illinois and Indiana where paving brick, and other clay products will, in the future be used in quantity. The people of Daviess County should see to it that one or more factories are soon erected for utilizing on a large scale some of the excellent clay materials which occur within the county limits.

MARTIN COUNTY.

Near the center of the southwestern fourth of the State is the county of Martin, comprising an oblong strip of territory, 340 square miles in area. Its maximum length from north to south is 28 miles, and its greatest width 13 miles. It lies south of Greene, east of Daviess, north of Dubois and west of Orange and Lawrence counties.

Three geological epochs are represented in the surface rocks of the county, viz., the Coal Measures and Mansfield Sandstone of the Carboniferous and the Huron limestones and sandstones of the Lower Carboniferous Periods. The Mansfield Sandstone covers at least two-thirds of the area, the Coal Measures proper being found only in the southwestern corner and in irregular isolated patches on the tops of the higher hills and ridges of the central portion. The Huron Group is mainly confined to the eastern third, though it has been exposed along the streams north of the center and along White River to a point west of Shoals.

With the exception of the extreme northern portion, which is drained by Furse Creek into the West Fork, the entire county is drained into the East Fork of White River. This river is a stream of some importance, having its head in the eastern-central part of the State. It enters Martin County near the middle of its eastern border, and flows in many meandering curves to near the southwestern corner, where it turns to the west and forms a small portion of the southern boundary. From the north part of the county it receives Indian and Boggs creeks, while from the eastern and southern portions Beaver Creek and Lost River enter.

The abundant shales which give to Daviess County on the west so much of its level character are here wanting, and massive sandstones and limestones prevail. Moreover, most of the county is unglaciated. It, therefore, has all the characteristic ruggedness of a region in which these conditions prevail. White River and its main tributaries have been the chief agents in carving the surface rocks into fantastic shapes and ploughing those deep gulches and valleys which are so prominent a part of the scenery of the county. In the northern portion, between Indian and Boggs creeks is an almost continuous ridge from 100 to 250 feet above the valleys. From it project numerous nearly level arms between the branches of the two creeks. East of Boggs Creek the county is so broken that the greater part of it can not be cultivated. South and east of White River the surface is still more rugged than that north of White River, due to the Mansfield sandstone here being more massive and probably thicker. As before, the ridges are narrow on top, the valleys broad. Often the Mansfield sandstone produces high perpendicular bluffs, or nearly as steep slopes, 50 to 100 feet high.

The one thing most needed in Martin County is a north and south railway. Two railways cross the county from east to west, viz., the B. & O. S. W. near the center and the Southern Indiana across the northern third. With a north and south road to connect the two, many of the undeveloped resources of the county could be put to use.

Coal I, at the base of the Mansfield sandstone and resting on the Huron limestone or sandstone is the principal coal found in Martin County. It ranges from 0 up to three and a half or four

feet in thickness, usually has a good vein of under-clay beneath, and often is overlain with shale. Where long exposed in the slopes of hills, its under-clay has weathered into a fine quality of potters' clay.

Again in a number of places the coal is lacking, and in the same horizon lies a bed of kaolin. This shows well at Johnson and Chenoweth's coal mine and kaolin bank on opposite sides of Millstone branch west of Shoals. In eastern Martin and Lawrence counties the coal is commonly wanting, while kaolin occurs at its horizon.

Coal III is the only member of the Coal Measure veins found in the county. As noted above, it occurs only in the slopes or crests of the higher and more prominent hills. The under-clay beneath this coal can be made into a variety of products.

Townships 5 and 4 North, Ranges 3 and 4 West.

This area of 150 square miles lies in and comprises the greater portion of the northern half of the county. The Southern Indiana Railway runs east and west near its center. The coals and shales are confined to the western half of the area.

In the southwest quarter of section 31 (3 N., 3 W.), the Southern Indiana Railway runs through a tunnel several hundred feet in length. Coal III occurs on the highest part of the ridge, but is cut out across the low places over the tunnel. At the eastern end of the tunnel the following section is exposed:

Section at East End of Tunnel on S. I. Railway.

	<i>Feet.</i>	<i>Inches.</i>
1. Sandstone, hidden.		
2. Gray sandstone	6	0
3. Blue clayey shale.....	10	0
4. Sandstone	4	0
5. Shale	10	0
6. Sandstone	3	0
7. Shale	10	0
8. Coal I		8 to 10
9. Sandstone	1 to 3	0
10. Shale with thin beds of limestone.....	20	0

Shale 3, and parts of 5, 7 and 10 can be made into vitrified wares of many kinds. Nos. 5 and 7 probably contain too high

a percentage of silica to work into hollow goods, such as sewer pipe, building block, etc. For these wares the upper and lower shales will be found most suitable. The more sandy middle shale will make paving brick for streets, and either stiff or soft mud bricks for building purposes. At the west end of the tunnel the shales above coal I are cut out by a fault, but No. 10 shale, with thin layers of interbedded limestone is 15 feet thick.

Just west of the tunnel the strata are faulted with a downthrow of about 40 feet to the west. This brings coal III well down into the hill, though it is still 50 or 60 feet above coal I. It is there three feet four inches thick, including seven inches of bone coal at the bottom. It is overlain by eight inches of shale and bone, then by 15 feet of blue shale, the latter of good quality for vitrified products.

At the Field bank, in the northwest quarter of section 5 (5 N., 3 W.), coal III is two feet three inches thick, with 10 feet of workable blue clay shale above. At the Porter bank, in the northwest of 6 (5 N., 3 W.), a good vein of under-clay lies beneath the coal, as also at the Smith mine, in the northwest of section 9.

At the Boggs Creek cut, on the Southern Indiana Railway, northeast corner of section 4 (4 N., 4 W.), the following section is exposed:

Section at Boggs Creek Cut.

	<i>Feet.</i>	<i>Inches.</i>
1. Yellow surface clay	1	0
2. Thin sheety shale	2	0
3. Coal I	0	4
4. Under-clay	2	8
5. Gray clayey shale	14	0

Both under-clay and shale are suitable for many kinds of vitrified wares, such as paving brick, sewer pipe, hollow brick, etc. With a railway on the spot and plentiful fuel a few miles to the northwest, the clay deposits along this cut will well justify the erection of a large clay manufacturing plant.

In 4 north, 3 west, coal I, nearly three feet thick, is mined at the Payton & Craig banks in the southeast quarter of section 6. Above the coal is blue clayey shale and below it a fair bed of under-clay. In the northwest quarter of section 17 the same vein of coal overlies three feet of under-clay.

Three-fourths of a mile south of the old site of the Indian Springs Hotel, in the northwest quarter of section 20 (4 N., 3 W.), is a large deposit of kaolin which, a number of years ago, was worked for some time, but is now abandoned. A horizontal shaft enters the side of a large hill, and on entering it a soft, shelly pinkish sandstone is seen above the deposit. Several tons of the pinkish brown variety of the kaolin were beneath a shed to which a tramway from the mine was constructed. Numerous pieces of lamellar iron ore, which had come from near the base of the kaolin stratum, were scattered about the mouth of the shaft. In the side entries, 100 to 150 feet back from the entrance, the upper half of the vein of kaolin, here four and a half feet thick, was pure white, and almost equal in quality to the best of that found at the main exposure near Huron, Lawrence County. At the time of my visit no one was present at the mine and I could not ascertain what disposition had been made of that taken out, nor why the mine had been abandoned.

Townships 3 and 2 North, Ranges 3, 4 and Part of 5 West.

In this area of 156 square miles, occur some of the most available shale and under-clay deposits of Martin County. In 3 north, 3 west, east and north of Shoals, only coal I occurs and it is found above drainage. In the northeast quarter of section 26 the coal is 17 inches thick, with six feet of clay shale above, and two feet of under-clay beneath. In the southeast quarter of section 18 it is overlain by two feet of shale and has two feet of under-clay beneath. Outcrops of kaolin at the horizon of coal I are exposed in the northeast quarter of section 15 and the southwest of section 14 (3 N., 3 W.), but the thickness of the beds is not known.

In the northeast quarter of section 1 (4 N., 4 W.), near the base of the north slope of the hill on which the town of Dover Hill is located, occurs a fine exposure of kaolin. Here, on the land of James Yarnell, a slope shaft about 50 feet long, and constructed in a crude manner, was put in a few years ago to determine the thickness and quality of the stratum. Above the kaolin is a soft, pinkish sandrock, which crumbles readily when exposed to air. At the time of my visit the props supporting this

roof had in places decayed away and allowed the crumbling sandstone to fall down and cover the entry to the depth of several feet, so that much difficulty was experienced in getting into the shaft. Once in, the kaolin stratum was found to vary between four and five feet in thickness. This, for the most part, was an amorphous pinkish brown material, made up of small granular masses. The color was evidently due to its being impregnated with oxide of iron by the leaching of the surface waters through the overlying sandstone.

In the upper part of the stratum were many nodular masses three inches in diameter or less, and exteriorly somewhat resembling geodes in appearance. These were easily broken by the hands, the interior being a soft pearly white, opal-like mass of pure kaolin. When exposed to the air this loses its transparent properties, and hardens in a few weeks into a flint-like body. At intervals in the stratum of kaolin are found large irregular masses of hard gray limestone, containing many fragments of crinoid stems and other small fossils. At the base of the stratum numerous rough, lamellar masses of iron oxide (limonite) averaging about six inches in thickness are often found. These rest upon a dark soapstone or shale, the depth of which could not be determined. A careful examination of the surroundings leads me to believe that the stratum of kaolin will thicken somewhat, and become much purer in quality farther back under the hill. The same stratum outcrops again on the south and west sides of the hill or ridge upon which Dover Hill is situated, and undoubtedly underlies the whole ridge at a depth of 125 to 140 feet. The greater part of this tract of land belongs to Dr. A. W. Porter, of Loogootee.

South of White River and west of Shoals coal I lies just above drainage. At the Johnson and Chenoweth bank, two and a half miles west of Shoals and a half mile south of the B. & O. S. W. Railway, in the northeast quarter of section 27, coal I is from two feet six inches to three feet six inches thick, with from six inches to three feet of black shale separating it from the Mansfield sandstone, which is here conglomeritic and massive, 40 to 50 feet thick. Below is three feet and over of a good quality of under-clay; then comes the Huron limestone. Coal was mined at

this point at a very early day, and shipped down the river in flat-boats. An attempt was at one time made to mine this coal extensively and carry it across the river on a wire rope, but the equipment failed to work satisfactorily, and the attempt was abandoned. Just east of this, across a small branch known as Millstone branch, the coal is replaced by a bed of kaolin, into which a slope or drift shaft, 40 feet long, has been excavated. The kaolin here is four and a half to five feet in thickness, but is not uniform in character, three or four varieties being mixed and interstratified in irregular layers. Of these the uppermost is a hard, semi-transparent, milky colored clay; the next lower a soft chalky white to cream colored; the third layer, a hard dark amber brown to black, containing much iron oxide, and the fourth or bottom layer a dirty yellowish brown clay of much hardness. According to Ashley, it might be said that "coal I had here been burned out, kaolinizing the under-clay, which is now all that lies between the Huron limestone and the Mansfield sandstone, which rises in a bluff above it for 40 feet." The shaft was put in more for prospecting purposes than anything else, and but little of the kaolin has as yet been used. A bore put down on the opposite side of the ridge proved the presence of this kaolin stratum at a depth of 40 feet.

A pottery was established at Shoals about 1870, and continued in operation until 1892, when it was merged into the Indiana Clay and Specialty Works, which for a time manufactured stoneware, vases, etc., on an extensive scale, but on account of disagreement among the owners was finally abandoned. The clay used was of two kinds, and was secured at Sampson's Hill, two miles southeast of Shoals, in the southeast of the northeast of section 6 (2 N., 3 W.), where the following section was obtained from the top of the hill through the under-clay of coal IIIa:

Section at Sampson's Hill.

	<i>Feet.</i>	<i>Inches.</i>
1. Upper slope, loose fragments of gray sandstone not in place	15	0
2. Dark blue potters' clay.....	6	0
3. Shaly impure coal IIIa.....	1	0
4. Light gray sandy under-clay.....	4	6

Of these, Nos. 2 and 4 were combined in varying proportions according to the kind of wares required. Both are good clays for stonewares, terra cotta and hollow block, being comparatively free from impurities and containing silica in the proper proportion to prevent the wares from air-cracking while drying and cooling.

On the Fordice land, in the northeast quarter of section 6, the same clays have been worked in connection with coal IIIa, here 15 inches thick. On the south side of Sampson Hill, in the southwest of the northwest of section 5 (2 N., 3 W.), coal III is mined. It is here three or more feet in thickness, and overlies a four to five foot bed of dark gray potters' clay.

In the vicinity of Loogootee, near the western edge of Martin County, occur a number of deposits of shales and under-clays worthy of development. Loogootee is a growing town of about 2,000 population, located on the B. & O. S. W. Railway. Natural gas has been found over quite an area just south of the town, and is used for heating and manufacturing purposes. Some of the under-clays in the vicinity have been used for a long time by local potters.

About two miles north of Loogootee a small pottery was started in 1842 by Upton Stucky, and continued in operation until 1892. The clay used was obtained on an adjoining farm, now owned by Mrs. Charlotte Wood, where it outcrops along a branch of Little Boggs Creek from beneath coal I. The stratum of clay is here three feet thick and is obtained by easy stripping. The same clay outcrops in one or two other places on the same land, but the stripping necessary to get at it is more extensive. It is also exposed in ditches along the Burns City Pike, between Loogootee and the Woods farm. According to Mr. Stucky, it makes a "nice blue stoneware which does not check in drying." Two other potteries have, in the past, drawn their supplies of clay from this same deposit.

On the Van Hoy land, just south of that of Mrs. Wood, in the northwest quarter of section 13 (3 N., 5 W.), a coal outcrops, and the following section was obtained:

Section on Van Hoy Farm, a mile and a half north of Loogootee.

	<i>Feet.</i>	<i>Inches.</i>
1. Surface	4	0
2. Sandstone	12	0
3. Shale	1	0
4. Coal	1	3
5. Under-clay	7	0
6. Shale	10	0
7. Limestone, impure	1	4
8. Shale	9	0
9. Coal		6
10. Under-clay	3	0

Of the strata given, Nos. 5, 6, 8 and 10, aggregating 29 feet, will be found suitable for many kinds of clay products. One or two of the shales mentioned also outcrop along the roadside between here and Loogootee.

A yellow loess clay of excellent grade occurs as a surface deposit in the immediate vicinity of Loogootee. In the eastern suburbs of the town it is used on a large scale by Lawhead Bros. and Moran Bros. in the making of soft mud brick, both firms having a combined output of two and a half million during the season of 1904. Their plants are located on spurs of the B. & O. S. W. Railway and the clay, used to a depth of six to nine feet, requires no stripping and is free from lime pebbles and all other impurities. The brick are burned by natural gas, which cost 10 cents per 1,000 cubic feet in 1904, averaging about 75 cents per 1,000 brick for the burning. The same yellow loess clay is exposed along the B. & O. S. W. Railway both east and west of Loogootee, and sites for many brick factories are there available. It could be used for pressed front brick and, mixed with the underlying shale, for a variety of clay wares.

On the John S. Larkin farm, one-half mile east of Loogootee, the upper portion of a blue clayey shale deposit is exposed to a thickness of three or more feet for a hundred yards or more up a shallow ravine. It is overlain with from two to eight feet of yellow loess clay and gravel. In an oil well on the same farm the shale stratum was found to be 50 or more feet in thickness. Samples of shale from the Larkin outcrops were analyzed by Dr. Noyes, and their composition found to be as follows:

Analysis of Shale from Larkin Farm, near Loogootee.

Silica (SiO_2)	59.64
Titanium oxide (TiO_2).....	.70
Alumina (Al_2O_3)	18.93
Water, combined (H_2O).....	5.88
<hr/>	
Clay base and sand.....	85.15
Ferric oxide (Fe_2O_3).....	1.62
Ferrous oxide (FeO).....	5.01
Lime (CaO}) .....	.85
Magnesia (MgO)	1.80
Potash (K_2O)	3.66
Soda (Na_2O}) .....	.81
<hr/>	
Fluxes	13.75
Carbon dioxide (CO_2).....	2.22
<hr/>	
Total	101.12

The shale is a light blue, gritless material, and the analysis shows its chemical fitness for making all kinds of vitrified products, such as paving brick, sewer pipe, hollow brick, etc. Its composition is very near that of the standard, mentioned on page 82. Mr. Noah Moser, a banker at Loogootee, showed me samples of dry-pressed front brick made from the shale by C. W. Raymond & Co., Dayton, Ohio. They were very hard and tough, a uniform dark cherry red in color, and a high-grade brick in every respect.

Just north of the Larkin land Mr. Moser owns 38 acres underlain by the same stratum of shale, the latter outcropping on the western slope, within 200 yards of the main line of the B. & O. S.-W. Railway. A small tract of lowland at the foot of the slope and nearly on a level with the railway grade offers an excellent site for a clay industry. In a test well put down on the line between the Larkin and Moser lands, to secure samples for burning, the shale stratum was 25 feet 6 inches thick, and its bottom not reached. Enough is exposed on the slopes, with easy stripping above, to last a large factory for many years.

On the Joseph Cannon farm, half a mile southeast of Loogootee, is a bed of light gray potters' clay, which has been used for 26 years in a pottery in the town.* The owner, John H. Folks, makes stoneware, flowerpots, etc., from the clay, and finds it in every way suited to his purpose. The stratum of potters' clay is

*For description see under Section IV.

nearly five feet thick and underlies a thin vein of coal. Above it is five feet of yellow loess clay, which must be stripped. In 1903 Mr. B. Reily operated this clay bank, and shipped 43 carloads, or almost 1,200 tons, of the potters' clay to the John Bauer pottery, at Louisville, Ky. He paid 10 cents per ton royalty and \$1.00 per ton freight, besides the expense of stripping and getting out and loading the clay, so that the latter cost the Bauer Company about \$2.25 per ton at Louisville. They pronounced the clay of fine quality, better than the Huntingburg potters' clay for their purpose, but considered the freight charges too high, and hence abandoned the bank.

With such a variety of yellow-loess potters' clays and shales in the vicinity; with cheap fuel, either natural gas or coal, and with a prominent railway like the B. & O. S.-W. all at hand, the citizens of Loogootee should put forth sufficient energy to locate several clay industries of large size near the town.

DUBOIS COUNTY.

Dubois County is located in the southwestern part of the State, and is bounded on the north by Daviess and Martin, on the east by Orange, Crawford and Perry, on the south by Perry, Spencer and Warrick, and on the west by Warrick and Pike counties. In general shape the county is rectangular, with an uneven northern boundary and southeastern corner. Its maximum length from north to south is 22 miles and greatest width 21 miles, its area being about 426 square miles.

Three geological epochs are represented in the rocks of the county, viz., the Huron limestones and sandstones of the Lower Carboniferous and the Mansfield Sandstone and Coal Measures of the Carboniferous Periods. The rocks of the Huron group occur only in small isolated areas along Patoka River and its tributaries in the northeastern part of the county and along the headwaters of Anderson Creek, in the southeastern corner. The Mansfield sandstone covers the greater part of the eastern third of the county, and at the points mentioned has been eroded through, thus exposing the underlying Huron rocks. The Coal Measures cover, for the most part, the western two-thirds, but on the higher ridges reach the eastern boundary of the county.

The eastern, and especially the northeastern, townships, where the Mansfield Sandstone forms the surface rocks, are broken with numerous hills and ridges, the hills in many places rising from 75 to 200 feet above the creek and river valleys. To the southwest, along the Patoka River, and west of Huntingburg, the hills are not so high and precipitous, running from 50 to 150 feet in height, usually with rather gentle slopes. The northwestern portion is more level and underlain with the Coal Measures strata, though being deficient in railway facilities, but few mines are worked, and they only to supply the local trade.

The county is abundantly supplied with water courses. The East Fork of White River forms the greater part of its northern boundary, and the northwestern corner is drained through a number of small streams directly into it. The Patoka River, a slow, sluggish, very meandering stream, flows in a southwesterly direction through the center of the county, and its numerous branches ramify through the eastern and southern areas. Its main tributaries are Lick Fork, Beaver, Straight, Henley and Elk creeks and their smaller branches. Anderson Creek flows across the southeastern corner and Pigeon Creek rises in the southwestern corner, both flowing southwesterly into the Ohio River.

The St. Louis Division of the Southern Railway and its branches furnish the only transportation facilities of Dubois County. The main line, between Louisville and St. Louis, crosses the county from east to west, a little south of the center. From it, at Huntingburg, diverge the Jasper branch, running north to Jasper, the county seat, and the Evansville branch, running south to Lincoln City, and then southwest to Evansville. The northern half of the county is wholly lacking in railway facilities.

Coals IV, III, IIIa, II and I, with their intervening shales and under-clays, occur in the county, coal IV being limited to the western third.

Township 1 North, Parts of Ranges 3, 4, 5 and 6 West.

This area of about 65 square miles lies along the northern border of the county, 12 to 20 miles from the nearest railway.

At the W. A. Line mine, in the northwest quarter of section 15 (1 N., 3 W.), a section showed:

Section at Line Mine.

	<i>Feet.</i>	<i>Inches.</i>
1. Surface.		
2. Gray, rather soft shale.....	3	0
3. Coal II	2	10
4. Dark gray clay.....	10+	

Shale and under-clay Nos. 2 and 4 can both be used for various clay wares. The coal lies about 35 feet above the bed of the branch below it. The same bed of coal and underlying clay outcrops in the southeast corner of section 18.

Coal I, with a fair grade of under-clay which, when weathered, will make a good potters' clay, outcrops in the southeast quarter of section 20, the northwest quarter of section 21 and the northwest quarter of section 34 (1 N., 3 W.). At the latter place coal I is mined at the Sutton banks, and the under-clay is nine feet thick and of good, workable quality. On the W. R. Combs land, in the southeast quarter of 20, the under-clay is 10 feet thick and rather hard and shale-like in appearance. It can be made into vitrified and ordinary brick, but is not of good quality for hollow goods. The survey of the proposed French Lick & Jasper Railway passes close to these deposits.

In township 1 north, 4 west, exposures of under-clay occur on the J. W. Neukom place, in the southeast of section 35, and on the W. Neukom farm, in the northwest of 32.

At both the Rudolph slope mine, in the southeast of 21, and Brittain's mine, in the southeast of 36 (1 N., 5 W.), the under-clay is three or more feet thick, and the overlying coal, IIIb, two feet ten inches thick.

Township 1 South, Ranges 3, 4, 5 and Part of 6 West.

In the eastern two-thirds of this area of 126 square miles only coals I and II occur, coal II being worked on the Cobbe farm, in the southwest quarter of section 35 (1 S., 3 W.), and on the Humbert farm, in the northwest quarter of 36 (1 S., 4 W.). At both places the under-clay was but about two feet thick and of inferior quality.

On the land of J. L. Schiller, southeast quarter of section 6 (1 S., 3 W.), occurs an outcrop of pale blue under-clay, three and a half feet thick. Through the lower part of it are scattered many

crystals of selenite (CaSO_4), varying in size from one inch in length downward. The owner burns the clay in a kiln, reducing these crystals to a powder, and then uses it as a fertilizer with good results. These crystals of selenite are found in numerous other deposits of under-clay east and north of Jasper, and have also been noted at other points in the State, as at Mecca, Parke County. The crystals are oftentimes acicular and, radiating from a common center, form little rosettes, which lie in great numbers on the exposed surface of the clays. With the exception of the one above given, no attempt, as far as known, has been made to utilize the clays containing them.

Jasper, the county seat of Dubois, is located in township 1 south, 5 west. One-half mile north of Jasper Reider Hill rises 140 feet above the level of the court house yard. A section of its upper 55 feet disclosed the following strata:

Section on Reider Hill, north of Jasper.

	<i>Feet.</i>	<i>Inches.</i>	<i>Feet.</i>	<i>Inches.</i>
1. Shaly sandstone	5	0	5	0
2. Light gray clayey shale.....	6	0	11	0
3. Coal IIb	2	6	13	6
4. Under-clay	2	6	16	0
5. Drab to blue clayey shale.....	20	0	36	0
6. Obscured	8	0	44	0
7. Limestone	6	0	50	0
8. Coal III	2	6	52	6
9. Under-clay	3+	0	55	6

Nos. 2 and 4, the greater part of 5 and all of 9 are of workable quality. No. 2 and the upper half of No. 5 are soft, fine-grained materials, which can be made into either vitrified or pressed front brick of high grade. The under-clays Nos. 4 and 9 are light-colored and plastic, and suitable to use for pottery, terra cotta or stoneware. The two veins of coal have been worked in several places by means of slope shafts, and the coal has been proven to be an excellent fuel. This hill, within one-half mile of the county seat, contains, therefore, not less than 25 feet of good commercial clay and the fuel necessary for its burning. A railway switch could be readily constructed past the furniture factory, in the east side of the town, and up the valley to the foot of the hill, where there is an excellent site for a large factory.

Three-quarters of a mile west of Jasper the "soapstone," or gray shale No. 2 of the above section, outcrops in numerous places along the roadside, and underlies the whole of the wooded tract known as "Military Park," northeast quarter of section 34 (1 S., 5 W.). Several slope shafts have been put in in this vicinity, and disclose a good quality of under-clay beneath the coal. Military Park is but three-quarters of a mile from the Jasper branch of the Southern Railway, and a switch easily constructed and of sufficient grade to allow cars to run by gravity to the main line could be built up the valley to the shale and clay. The entire area of section 34 is probably underlain with these deposits.

A drilled well on top of the hill in the southeast of the southeast of 28 (1 S., 5 W.), one and a fourth miles west of Jasper, disclosed the following strata:

Section in Hill west of Jasper.

	<i>Feet.</i>	<i>Inches.</i>	<i>Feet.</i>	<i>Inches.</i>
1. Soil and surface clay.....	16	0	16	0
2. Shaly sandstone	6	0	22	0
3. Coal IIIb	2	4	24	4
4. Under-clay	3	0	27	4
5. Hard reddish shale	11	0	38	4
6. White sandstone	28	0	66	4
7. Shaly sandstone	4	0	70	4
8. Coal IIIa	4	0	74	4
9. Reddish gray shale	26	0	100	4
10. Blue clayey shale	20	0	120	4
11. Flinty limestone	3	0	123	4
12. Coal III	4	0	127	4
13. Under-clay	3	0	130	4
14. Shale, blue	8	0	138	4

Here we have not less than 33 feet of clay working materials, and above them three veins of coal of workable thickness.

Townships 2 and 3 South, Ranges 3, 4, 5 and Part of 6 West.

This area of 216 square miles comprises the south half of Dubois County. Through it the Southern Railway runs, and in it occur the best-known commercial clays of the county. Over the eastern third of the area only the thin veins of coals I and II occur, and their under-clays alone form the workable clays of the region. Outcrops of these coals occur in the northeast quarter of

24, the southwest quarter of 26, the southeast of 27, the northwest of 34 and the northwest of 33 (2 S., 3 W.), all within half a mile or less of the Southern Railway.

Southeast of Bretzville one mile, in the west half of section 4 (3 S., 4 W.), occur some fine exposures of gray clayey shale along the road leading to Ferdinand. The outcrops of shale are here about 15 feet thick and overlain with three to five feet of yellow loess clay.

A short distance west of Bretzville, in the south half of section 32 (2 S., 4 W.), the Southern Railway passes through a cut in which 20 feet of drab clayey shale is exposed. The sub-conglomerate coal I outcrops at several places in the same vicinity, and has beneath it a dark, plastic under-clay suitable for terra cotta and stoneware.

At the Oeding mine, in the southwest quarter of section 30 (3 S., 4 W.), two miles west of Ferdinand, coal IIa, 18 inches thick, overlies eight feet of under-clay, suitable for many kinds of hollow vitrified wares. Beneath the under-clay is 10 feet of good, workable shale, and then the worked coal II, 2 feet 10 inches thick, which also overlies a good vein of under-clay.

Southeast of Ferdinand, in the south half of section 34 (3 S., 4 W.), are found large deposits of clay and decomposed iron ore, suitable for the manufacture of mineral paints. The "Anderson Valley Mining Company" erected a mill at Ferdinand and worked these deposits for a number of years. Their products were of excellent quality, and for a time were much used, but a lack of railway facilities caused the abandonment of the enterprise. From a flinty limestone above a seam of coal on the same section a polishing powder, called "tripoli," was obtained in quantity and put upon the market. The same material is found at several other points east of Ferdinand, notably in the northwest quarter section 26 and the northeast quarter of section 13 (3 S., 4 W.). Should the railroad projected between Rockport, Spencer County, and Mitchell, Lawrence County, be constructed, it will pass through this region, and these resources will become of much value.

At Huntingburg, an important junction point on the Southern Railway, there exists a thick stratum of one of the best potters' clays known to occur in Southern Indiana. For a number of years large quantities of it have been shipped to potters at Evans-

ville, New Albany, Louisville and other points along the Southern Railway, and for 27 years it has been used in a pottery at Huntingburg. The worked beds of this clay occur beneath a thin vein of coal IIIb in Beeler's hill, just northwest of Huntingburg, northwest quarter section 34 (2 S., 5 W.). A section of the Bockting Bros. clay pit, on the southeast slope of this hill, in August, 1904, disclosed the following strata:

Section at Bockting Bros.' Clay Pit.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil and yellow loess clay.....	4	0
2. Soft drab to blue clayey shale.....	17	0
3. Coal IIIb	0	10
4. Light gray under-clay—potters' clay.....	6	0
5. Under-clay with iron nodules.....	2	0
6. Soft gray clayey shale.....	9+	0

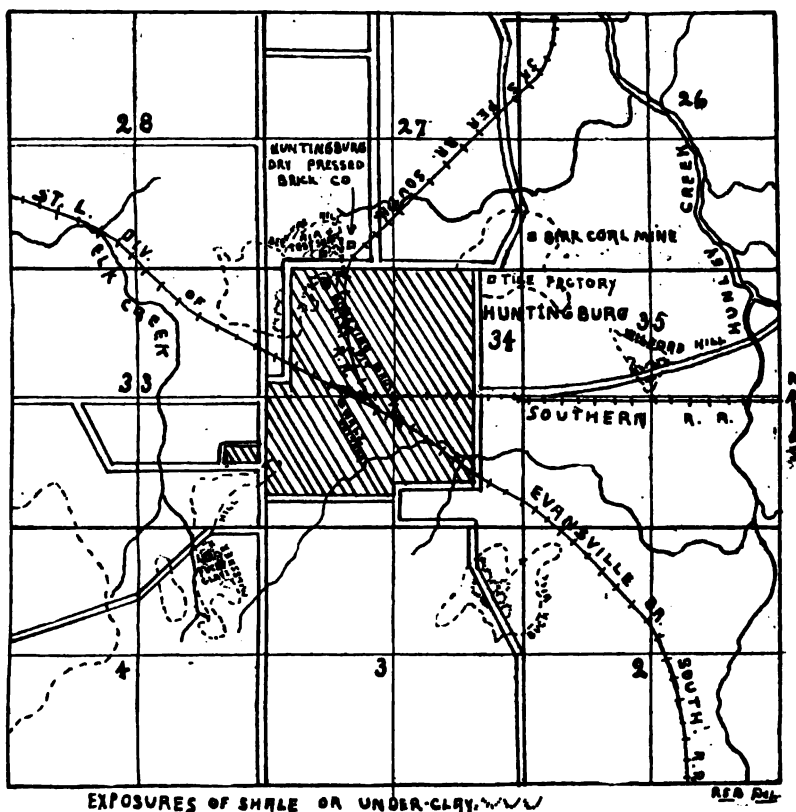


Fig. 11. Map of Huntingburg and vicinity, showing location of clay deposits.

The upper strata, Nos. 1 and 2, are stripped and used in making ordinary brick by the Bockting Bros. The under-clay is sold for stoneware, bringing \$1.25 per ton f. o. b. at the pit. Quite a quantity of the lower clay, No. 6, is also shipped to Louisville to be made into sewer pipe, etc., bringing 50 cents per ton at the pit.

The stoneware made from this potters' clay at Huntingburg and Evansville is strong, durable, and takes an excellent glaze. It does not air-crack in drying or in cooling after being removed from the kiln. The composition of the clay, as shown in an analysis made for Bockting Bros. by Dr. Noyes, is as follows:

Analysis of Potters' Clay from Bockting Bros.' Pit.

Silica (SiO_2)	69.23
Titanium oxide (TiO_2).....	1.50
Alumina (Al_2O_3)	18.97
Water (H_2O)	5.46
<hr/>	
Clay base and sand.....	95.16
Ferric oxide (Fe_2O_3)	1.57
Ferrous oxide (FeO).....	.55
Lime (CaO}) .....	.12
Magnesia (MgO}) .....	.36
Potash (K_2O)	2.27
Soda (Na_2O}) .....	.33
<hr/>	
Fluxes	5.20
<hr/>	
Total	100.36

This shows a composition approaching very closely the average standard of stoneware clays, and proves the superiority of this clay for pottery purposes.

The Huntingburg Dry Pressed Brick Company* has a large and well-equipped plant a short distance northeast of the pit worked by the Bockting Bros. They make from the yellow loess clay, here six to 10 feet thick, a handsome and durable red dry-pressed brick. This clay is of the same nature as that already mentioned as found about Washington, Loogootee, and other points, being fine-grained, free from foreign matter and homogeneous in texture.

The brick were being made from the loess clay for a little less than \$3.00 per thousand, which shows what can be done with that

*For description of plant see under "Clay Industries of Indiana."

material under the proper management. Besides the red dry-pressed brick from the loess clay, the company also makes a buff dry-pressed front brick, and fire brick from the potters' clay underlying the hill to the west, and from a mixture of the potters' clay and the underlying fire-clay, containing small grains of iron ore, a speckled or Pompeii front brick, which is in large demand. The small grains of iron ore in this lower stratum of fire-clay are most probably the ferric or sesquioxide of iron (Fe_2O_3). These are reduced by the influence of the heat and gases of the kiln to ferrous oxide (FeO). When subjected to higher heat a fluxing action begins and causes a chemical union between the ferrous oxide and any free silica in the clay, producing a black ferrous silicate, which is not affected by higher heat. The black specks, ranging in size from a pinhead to the cross section of an ordinary lead pencil, found in the Pompeii brick are composed of this silicate. These brick bring from \$12 to \$14 per thousand at the factory, as against \$10 for the buff, unspeckled brick. From the potters' clay this company makes the fire brick and floor tiling for their kilns. These stand up well under great heat, and prove the high refractory grade of the clay, as evinced by its chemical composition. The four large Eudaly kilns, lined and floored from these fire brick, have been in use ten years, and are still in good condition.

This company also ships large quantities of the potters' clay mined from a slope shaft to the John Bauer Pottery at Louisville and the Uhl Pottery Co. at Evansville, the shipments amounting to 150 cars of 35 to 40 tons each per year. For this they receive \$1.25 per ton f. o. b. the cars.

On top of Beeler's Hill, 300 yards southwest of their plant, the company put down a large air and test shaft through the stratum of potters' clay, which disclosed the strata in that part of Beeler's Hill, as follows:

Section in Beeler's Hill.

	<i>Feet.</i>	<i>Inches.</i>
1. Surface and yellow loess clay.....	14	0
2. Blue clayey shale	16	0
3. Dark bituminous shale	2	0
4. Coal IIIb	1	1
5. Potters' clay	5	10
6. Under-clay impregnated with small grains of iron ore	2	0
7. Soft gray clayey shale.....	7	0

All of these except No. 3, are valuable for manufacturing purposes. Both the upper shale, No. 2, and the lower, No. 7, are suitable for vitrified wares of many kinds. The bottom six feet of No. 2 would probably have to be rejected on account of too high a percentage of bitumen. With these shales present in such large quantities, an addition for the purpose of making vitrified brick would, without doubt, prove a valuable adjunct to the plant already in operation.

On the land of Fred. Weisman, in the southeast quarter of section 22 (2 S., 5 W.), a mile and a quarter northeast of Huntingburg, a fine deposit of under-clay occurs beneath a thin vein of coal. A shaft has been sunk through the clay on the north slope of a hill just west of the new Jasper-Huntingburg stone road and one-fourth mile west of the Jasper branch of the Southern Railway. A section of the shaft shows:

Section of Test Shaft on Weisman Land.

	<i>Feet.</i>	<i>Inches.</i>
1. Surface soil and clay.....	3	4
2. Coal IIIb	0	3
3. Under-clay	5	0
4. Shale	2+	0

The under-clay evidently belongs to the same stratum as the potters' clay used at Huntingburg. It is a soft, light gray, plastic material, free from all grit and impurities, and a high-grade clay in every particular. It can be made into terra cotta, sewer pipe, hollow brick and all kinds of hollow vitrified wares and stoneware. Hunley Creek, with a plentiful supply of water, lies one-eighth of a mile to the north. The clay stratum will be found under the entire hill of 30 or more acres. On the lower ground on the west side of the hill, and about 300 yards from the test shaft, a three-foot vein of coal III of good quality is being mined at a depth of 45 feet. The top of the shaft starts below the level of the under-clay No. 3.

At the Bretz mine, in the northwest quarter of the northeast quarter of section 27, coal III is also mined. Over it is 12 feet of gray clay shale, while the floor is a light blue under-clay, with here and there patches of gray shale and sandstone, with stigmaria.

One-half mile east of Huntingburg, near the center of section 35 (2 S., 5 W.), the Bretzville macadam road cuts through Wix-

ford Hill. A section of the exposed strata on the east side of this hill shows as follows:

Section on east side of Wirford Hill.

	<i>Feet.</i>	<i>Inches.</i>	<i>Feet.</i>	<i>Inches.</i>
1. Surface and yellow loess clay.....	5	0	5	0
2. Soft massive sandstone.....	6	0	11	0
3. Rather hard sandstone.....	1	0	12	0
4. Under-clay	2	6	14	6
5. Shale, gray sandy	5	0	19	6
6. Hard, flinty, disintegrating limestone	1	0	20	6
7. Under-clay with coal streak.....	3	0	23	6
8. Shale	12	0	35	6

The surface clay No. 1 and the under-clays Nos. 4 and 7 are suitable for many kinds of products. The surface clay burns to a handsome brick-red hue. The under-clay No. 4 is a light gray, plastic material, and has a thin showing of coal above it. It merges gradually into the sandy underlying shale. The main line of the Southern Railway is about 150 yards south of this hill.

On a hill just northeast of Huntingburg William Lukemeyer has been making drain tile since 1893 from a mixture of two-thirds surface clay and one-third under-clay from Beeler's Hill. The surface clay used is first stripped of four to six inches of black dirt, and then used to a depth of four feet. The tile are a bright cherry red in color, and appear of good quality.

The pottery of V. Walz, near the center of Huntingburg, has been in operation since 1880. The clay used is the potters' clay from Beeler's Hill, Mr. Walz owning an acre of ground back of the brick factory. At his pit the potters' clay is five and a half feet thick and is overlain with about 16 feet of shale.

South of Huntingburg one mile, in the east half of section 3 (3 S., 5 W.), is Buck Hill. The Ferdinand macadam road crosses this hill, and in cuts and ditches made in grading an under-clay four feet in thickness and a shale six to eight feet thick are exposed on the north slope. Above the under-clay is a thin vein of bone coal, about three inches in thickness. The shale is probably the same stratum as that found above the potters' clay in Beeler's Hill, and both it and the under-clay above it can be made into vitrified wares of many kinds. The entire hill, comprising an area of 150 or more acres, will be found to be underlain with the under-

clay and shale, and at several points their outcrops can be reached by a switch less than one-fourth mile in length.

One-half mile southwest of the center of Huntingburg is Milssner Hill, a long, narrow elevation, crossed by the Holland road. On it, in the northeast quarter of section 4 (3 S., 5 W.), Chris. Fuchs owns 40 acres, which is almost wholly underlain with the stratum of potters' clay found in Beeler's Hill. In a well sunk on the Fuchs place this clay was found to be 14 feet thick and bottom not reached. It is overlain with three to five feet of yellow loess clay, and in places along the Holland road the overlying shale exposed on Buck Hill also outcrops. A sample of the Fuchs clay was analyzed by T. W. Smith, of Indianapolis, and its composition found to be:

Analysis of Clay from Chris. Fuchs' Land.

Silica (SiO_2)	65.25
Alumina (Al_2O_3)	17.30
Water, combined	5.40
<hr/>	
Clay base and sand.....	87.95
Ferric oxide (Fe_2O_3).....	2.30
Calcium (CaO}) .....	.50
Magnesia (MgO}) .....	.20
Potassium (K_2O)	1.56
Sodium (Na_2O}) .....	.98
<hr/>	
Fluxes	5.54
Moisture	6.50
<hr/>	
Total	99.99

The analysis shows the material suitable as the clay ingredient of Portland cement. It is also a high-grade refractory material, of the same general composition as the Bocking Bros. deposit, and can be used for the same purposes. This potters' clay is known to underlie an area one mile wide and two to three miles long between Huntingburg and Holland. It also occurs, as we have seen, a mile and a half northeast of Huntingburg. Careful investigation will prove its presence in many places where it is not now known to occur. It is the best clay-working material in Dubois County, and should be much more extensively developed.

Just south of the Patoka River, in section 15 (2 S., 6 W.), and about five miles northwest of Huntingburg, the Southern Rail-

way has recently deepened a cut and exposed a thick stratum of shale of excellent quality for vitrified wares. This shale runs 25 feet or more in thickness, with bottom hidden. It is that soft gray, gritless material, commonly known as soapstone, which forms one of the best varieties of shales for manufactured products. With water, cheap fuel and railway all present, this site offers excellent inducements to persons wishing to erect a large clay factory.

Samples of a very light gray, plastic potters' clay have been sent in from the land of F. M. Battles, near the western edge of Dubois County, southeast quarter section 10 (2 S., 6 W.), two miles east of Velpen, Pike County, and less than a mile north of the Southern Railway. In a letter Mr. Battles states that the clay will run from seven to 10 feet thick. It occurs beneath a bed of shale over 40 or more acres. Samples have been tested by the Uhl Pottery Co., of Evansville, and pronounced of good quality for stoneware.

More than anything else, Dubois County needs railways. When these are constructed, new mines will be opened up, new deposits of shales and under-clays exposed, and, it is to be hoped, put to ready use. Meanwhile, a number of those above mentioned merit development. The ones along the Southern Railway in the vicinity of Huntingburg and Jasper will, as we have seen, furnish material of excellent quality and in almost unlimited quantity for the making of vitrified brick, sewer pipe, pressed-front brick, stoneware, hollow brick and terra cotta. Where clays suitable for such varied products occur in one locality, capital is bound in time to find them and put them to use. How soon that capital will be invested in their development depend solely upon the energies of the people of the towns near which the deposits lie.

PIKE COUNTY.

This county comprises an area of 336 square miles, lying just south of White River, in the southwestern part of the State. It is bounded on the north by Daviess and Knox, on the east by Dubois, on the west by Gibson and on the south by Warrick and Gibson counties. Its extreme length from north to south is 22 miles and greatest width from east to west 21 miles.

The entire surface of Pike County is covered by the Coal Measure rocks of the Carboniferous Period. The thickest veins of coal found in Indiana lie within its bounds. Vast beds of shale and clay cover and underlie these coals, bringing thus in close proximity the materials for fireproof products and the fuel to manufacture them.

The northwestern part of the county is generally level or rolling. From Petersburg eastward the divide between Patoka and White River is level. To the north, as White River is approached, the surface is cut up somewhat by the drainage. To the south the old lake filling and prairies drained by Flat Creek are found. South of this the surface becomes more hilly; then come the slopes and broad bottoms of Patoka River. South of Patoka River the topography shows high, irregular divides, with usually broad stream basins, the high land culminating in the divide between the Patoka River and the Ohio, which often rises in the form of conical knobs, 150 to 175 feet above the neighboring drainage. The drift appears to have covered only the northern part of the county, not extending much, if any, south of the base line until it has passed south of Petersburg, when the limit swings off to the southwest. Over this area the drift tends to have a variable depth, depending largely on the pre-glacial topography, so that in places it becomes quite deep. The soils of the western and northern parts of the county produce good crops of wheat, oats, corn and grass.

White River forms the northern boundary of the county and drains the northern third, receiving therefrom Beech, Pond, Mud, Pride's, Conger's and Harbin's creeks, in the order named, from east to west. The Patoka River, a sluggish, muddy stream, flows from east to west across the center of the county, and drains its greater portion. Its main tributaries from the north are Flat, Stone, Coal and Sugar creeks, while from the south it receives Rock, Cup and Barren creeks and South Patoka River, with its many tributaries.

The railway facilities of the county are somewhat meagre. The E. & I. crosses from north to south, a little west of the center, while the St. Louis Division of the Southern runs from east to west near the center. On account of the peculiar shape of the

county, more than two-thirds of its area is distant three to 15 miles from either of these lines.

Coals VII and VIb occur in workable thickness over the north-western portion of the county west of the E. & I. Railway and in a small outlying hill north of Petersburg. Coal V is the prominent workable vein over the western two-thirds, while coals IV, III, IIIa and IIIb outcrop in the eastern part of the county, and in places are of workable thickness. Coal VII is usually directly overlain with clay shale, which, with the under-clay beneath, is good clay-working material. The under-clays below coals VIb, IV and IIIb are the best suited for manufacturing purposes. The under-clay below the main vein, coal V, is in general too hard and dark-colored and contains too much sulphur and other impurities to make clay wares.

Township 1 North, Parts of Ranges 6, 7, 8 and 9 West.

This area includes about 90 square miles, or a strip three to six miles wide and 21 miles long, across the northern boundary of the county. Coal VII covers about 38 square miles of the area west of Petersburg, the county seat, while the eastern portion is about equally divided between coals V and IV, as the surface veins.

At the ferry across White River, north of Long Branch Post-office, in the southeast quarter of section 7 (1 N., 6 W.), six feet of gray to brown sandy fire-clay is seen near the top of the river bank, while the thin vein of coal IIIb, six feet lower down, overlies three feet of a good quality of drab under-clay.

At Carlisle's bank, in the northeast quarter of section 10 (1 N., 7 W.), coal IV, three feet six inches thick, is worked about 75 feet above the river, and overlies three feet nine inches of under-clay suitable for many kinds of clay wares. At High Banks, in the southeast of section 14, the same vein of coal overlies five feet of the same grade of under-clay.

At Sand Hill, north half of section 22 (1 N., 8 W.), one and a half miles north of Petersburg, the following section is exposed:

Section at Sand Hill, north of Petersburg.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil and sand.....	18	0
2. Gray sandy shale.....	7	0
3. Coal VII	3	10
4. Under-clay	3	8
5. Blue clayey shale, soapstone.....	8	0
6. Gray sandy shale.....	6	8
7. Dark limestone, fossiliferous.....	2	4
8. Bituminous shale, containing nodules of pyrites. 1		8
9. Coal VIb	2	10
10. Under-clay	8	0

The two under-clays, Nos. 4 and 10, and the blue shale, No. 5, comprise, together, almost 20 feet of the best of material for manufacturing street brick, terra cotta and many kinds of vitrified products.

Northeast of this, at Blackburn, northwest quarter of section 13 (1 N., 8 W.), on the E. & I. Railway, the under-clay beneath the seam of worked coal V is hard and dark-colored, with too many nodules of iron carbonate to be of use. The shale above is in thin layers and full of mica, rendering it almost worthless. This bed of micaceous shale outcrops along the railway to the southward for half a mile or more, being overtopped for the greater part of this distance with a massive gray sandstone. It may be laid down as a general rule that when the shale splits, as this does, into layers or laminæ less than one-half an inch thick, it is unfit for manufacturing purposes.

At the Smith mine, southeast of northeast of 13 (1 N., 8 W.), the strata exposed are as follows:

Section at Smith Mine, northeast of Petersburg.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil and yellow clay.....	8	0
2. Sandstone, micaceous, shaly.....	10	0
3. Blue compact shale.....	14	0
4. Coal	9	10
5. Under-clay	??	0

The vein of coal at this point is the thickest I have seen in the State. Standing on the lower unworked part of the seam, one foot six inches in thickness, I could just reach, with a miner's pick, the roof at the top of the worked portion, the clear, unbroken seam of the latter being eight feet eight inches thick. If the mouth

of the shaft had been made wide enough an ordinary two-horse wagon could have been driven into the mine and loaded directly from the vein. Although the seam of coal ranks among the best bituminous, it is at present worked only to supply the local trade, the nearest railway switch being three-fourths of a mile distant. Only the upper part of shale No. 3 of the section given is fit for manufacturing, the lower six feet containing too much bitumen.

In the immediate vicinity of Petersburg, the county seat, numerous mines have been opened, mostly by slope shafts. At the Meisenhelder shaft, just south of the E. & I. station, in the western part of the town, the following section was exposed:

Section at Meisenhelder Shaft in Petersburg.

	<i>Feet.</i>	<i>Inches.</i>
1. Surface soil and blue mucky clay.....	16	0
2. Blue clayey shale.....	6	8
3. Blue limestone, fossiliferous.....	10	4
4. Black sheety shale with kidneys of iron carbonate	3	10
5. Coal V	7	1

The blue shale No. 2 could be used in the making of a variety of clay wares. On George King's place, in the eastern part of Petersburg, 16 feet of drab to yellow clay shale forms the surface, and the same six-foot layer of blue shale occurs above coal V.

On the Stucky farm, a mile and a quarter northwest of the Court House, in the northeast quarter of section 22, is a mine formerly operated by Jerome B. Borer. A stratum of under-clay four feet thick is found beneath the worked seam of Coal VII. In the past many tons of this clay have been mined and hauled to Petersburg. There it has been made into strong and durable refractory bricks and flooring for kilns, grates, etc. Some of the brick were used by the maker in the flue arches of clamp kilns for 12 years, and others in the sides of a Eureka tile kiln for nine years, and then appeared as good as new. The clay was delivered at the brick plant in town for 85 cents a ton. The brick made from it have sold as high as \$18 to \$25 per thousand. The lower half of this vein of under-clay contains too many nodules of kidney iron ore to be of value.

At the Oliphant mine, near Union Postoffice, in section 32 (1 N., 9 W.), coal VII, four feet thick, is overlain with white clay shale, and has a bed of good, workable under-clay beneath.

Township 1 South, Ranges 7, 8 and Parts of 6 and 9 West.

Coal V, with its overlying black, sheety shale, is the principal vein worked in the eastern part of this area, and its under-clay is, in general, of inferior quality. The under-clay of coal VII, in the western part, is the principal clay-working material of the area.

At Thomas' Mill, in the southeast quarter of section 31 (1 S., 6 W.), coal IIIb overlies five feet and more of under-clay of good quality for many kinds of products.

Southwest of Petersburg, on the land of Hosea Alexander, a shaft located one-half mile from the E. & I. Railway, and less than five feet south of the base line, in the northeast quarter of section 4 (1 S., 8 W.), showed the following section:

Section of Alexander Shaft.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil and surface clay.....	10	0
2. Shaly sandstone	6	0
3. Gray sandy shale.....	4	0
4. Coal VII	4	8
5. Under-clay with numerous stigmaria.....	3	4

The under-clay found here is practically the same as that found at the Borer mine, above mentioned. It has been tested at the brickyard at Petersburg and found to make a good grade of refractory brick. The same grade of under-clay, averaging three or more feet in thickness, occurs below coal VII, at outcrops on the Miley places, in the northwest and southwest of 9 and the southeast of 8 (1 S., 8 W.); also at Rumbles' mines, near the center of section 17 (1 S., 8 W.), and at Carr's mine, in the southeast of section 13, and Miller Bros. and Falls mines, in the northeast of section 24 (1 S., 9 W.). In general, it may be said that the under-clay of coal VII, west of the E. & I. Railway in Pike County, will make hollow vitrified wares of good quality.

Township 2 South, and Part of 3 South, Range 7 and Parts of Ranges 6 and 8 West.

This area of 129 square miles comprises the southeastern portion of Pike County. Coal V is the principal coal mined in the area. Coal VII, with its under-clay, occurs west and south of

Pleasantville, in the southwestern corner, and coals IV, IIIb and III in the southeast.

In sections 7, 8 and 9 (2 S., 6 W.), near Velpen, a station on the Southern Railway, coal IV is in several places overlain with ten or more feet of gray, clayey shale of suitable quality for vitrified wares. One such outcrop is on the J. Risley place, in the southwest of the northwest of section 9, and another in the northeast of southeast of section 7. Coal IIIb, about 20 feet below coal IV, overlies a good, workable bed of under-clay.

At the Patoka bridge at Jonesboro, in the northwest quarter of section 19 (2 S., 5 W.), the following section is exposed:

Section at Patoka Bridge, Jonesboro.

	<i>Fet.</i>	<i>Inches.</i>
1. Slope of hill.....	10	0
2. Gray to drab clay shale.....	25	0
3. Black sheety shale.....	1	0
4. Coal IIIb	1	0
5. Dark drab under-clay.....	1	0
6. Light drab under-clay.....	4	0
7. Shaly sandstone	12	0
8. Massive sandstone	10	0
9. Gray shaly sandstone.....	15+	0

Nos. 2, 5 and 6 will be found suitable for many kinds of clay wares.

At Hartwell, on a spur of the Southern Railway, in section 22 (2 S., 7 W.), coal VI, three and a half feet thick, is overlain with 12 feet of light drab clay shale and underlain with three feet of under-clay. At the Hecock mine, in the southeast of 16 (2 S., 7 W.), the same coal is underlain with 8 to 10 feet of under-clay and gray clayey shale.

The under-clays beneath coals IV and IIIb, where exposed in this part of Pike County, run from three to five feet in thickness, and are light gray, siliceous and suitable for the making of terra cotta and hollow vitrified wares. In numerous localities a bed of soft, light gray shale, 12 to 15 feet in thickness, separates coal IV from the overlying sandstone. This shale is locally known as "soapstone," and, combined with the under-clay beneath the coal, will make a vitrified street brick of a superior grade. As coal IV appears to be a dry, semi-block coal of some purity, it may prove of value if mined in connection with the overlying shale. Such

deposits of shale are found in the southeast quarter of section 16, the northeast quarter of 23, and the northwest quarter of section 36 (2 S., 7 W.).

On the road near Fred. Corn's place, in the southwest quarter of section 35 (2 S., 7 W.), coal IV, three feet thick, is overlain with six feet of gray clay shale and underlain with 18 feet of the same material.

At McGregor Hill, in the southeast quarter of section 9 (3 S., 8 W.), two miles northwest of Pleasantville, coal VII is overlain with 10 feet of soft, dark gray, clayey shale, resembling an under-clay, and underlain by three feet of under-clay. Both strata will make many kinds of hollow vitrified wares.

Taken in connection with the thick and almost wholly undeveloped coal veins of Pike County, the clay deposits above mentioned should present attractive inducements to capitalists in search of paying investments. Both the E. & I. and the Southern Railways, with terminals in large cities, where immense sums are expended each year for clay products, stand ready to do their part in the development of the clay resources along their lines. The time will come—not very far in the future—when Pike will become one of the chief coal producing counties of Indiana, and then, let us hope, the value of the accompanying clays will be, to some extent, appreciated.

Surface clays, principally yellow loess in character, are used for making ordinary brick and drain tile at four or five yards in Pike County.* At the two yards near Petersburg the loess clay runs three to five feet thick, with little or no necessary stripping, and is of fine quality for soft mud brick. At Stendal it is six feet thick.

GIBSON COUNTY.

This county is near the southwestern corner of the State, and on its western border. It lies south of Knox, east of the Wabash River, or Illinois-Indiana line, north of Warrick, Vanderburg and Posey, and west of Pike and Warrick counties. It has an extreme length from east to west of 36 miles, and width from north to south of 25 miles, with an area of about 487 square miles, being one of the largest counties of the State, and at the same time one of the richer agricultural counties of Southern Indiana.

* See statistical table near end of paper.

The Coal Measure rocks cover the entire surface of the county, but it is only along its eastern margin that the veins of coal outcrop, and there only in a few localities. The western three-fourths of the county is very similar to that of western Knox, the veins of coal of workable thickness being overlain with from 200 to 400 feet of alternating strata of shales and sandstones. Such formations, containing only a few thin seams of "rash" coals, are known as the Upper or Barron Coal Measures. They form the surface rocks in parts of Sullivan, Knox, Gibson and Vanderburgh counties and in all of Posey County.

The eastern part of Gibson County is elevated and rolling, or, in places, plateau-like, with deeply cutting ravines. A few knob-like hills are found in this portion of the county. The western half is generally level or slightly undulating, with a large area of bottom land. The soil of the western two-thirds is very fertile, and produces some of the largest crops of corn and wheat grown in the State.

White River flows along part of its northern border, while the Wabash forms the rest of the northern border, the two together also forming the western border. Patoka River flows across the northern part of the county with a sluggish current. The southeastern quarter of the county drains to Pigeon Creek and the southwestern into swamps along the Wabash or into Black River.

The county is fairly well supplied with transportation facilities. The Evansville & Terre Haute Railway runs north and south and the St. Louis Division of the Southern east and west through the central portion, the two crossing at Princeton, the county seat. The Mt. Vernon Branch of the E. & T. H. leaves the main line at Fort Branch and passes through a small portion of the southwestern fourth. The E. & I. cuts across the southeastern corner, while the Peoria Division of the Illinois Central touches the southwestern corner.

Townships 2 and 3 South, Ranges 8 and 9 West.

In this area along the eastern border of the county, coal VII, with its underlying clay, occurs close to drainage. Just south of Dongola, in the northeast quarter of section 6 (2 S., 6 W.), the coal is separated into benches by a band of under-clay 20 inches

thick, while below the bottom bench is another layer of clay 15 inches thick. The clay is a soft dark gray material, well suited for terra cotta and hollow block manufacture.

At the Oakland quarry, just west of Oakland City, coal VII is underlain by four feet of an under-clay of the same quality. At the Charles North bank, north of Stumpsburg, the under-clay is of a soft blue character, and nearly three feet thick, gradually merging into a hard blue sandstone.

Southwest of Oakland City, northeast quarter of 24 (2 S., 9 W.), F. Cotterill is operating a mine, the worked vein of coal being 135 feet below the surface. Beneath the coal is a stratum of dark gray under-clay, eight feet in thickness. This has been used with good results by Mr. Cotterill for making fire brick for boiler walls and furnaces. A switch of the Southern Railway is completed to the mine.

One-quarter of a mile south of Buckskin, southwest quarter of section 27 (3 S., 9 W.), coal VI, in two benches, is mined at the depth of 63 feet. A section of the shaft at the mine, kindly furnished me by Andrew Dodds, Assistant State Mine Inspector, shows:

Section of Shaft at Buckskin Mine.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil	1	0
2. Stiff, ash-colored clay.....	4	0
3. Yellow clay	10	0
4. Hardpan	5	0
5. Blue clayey shale.....	17	0
6. Coal	2	0
7. Under-clay	2	0
8. Massive sandstone	8	0
9. Sandy blue shale.....	9	0
10. Gray shale with ironstone nodules.....	2	0
11. Hard gray sandstone.....		2
12. Soft gray shale.....	3	4
13. Coal VI?	3	5
14. Bone coal and "black jack".....	3	1
15. Coal VI?	2	0
16. Under-clay	5+	0

Shale No. 12, above the upper bench of coal, is a "clod," or layer of soft gray, gritless clay, of much the same character as a good grade of under-clay. An analysis of average samples of it sent in by Mr. Dodds was made by Dr. Lyons, and its composition found to be as follows:

Analysis of Shale above the Worked Vein of Coal at the Buckskin Mine.

	<i>Per Cent.</i>
Silica (SiO_2)	57.60
Titanium oxide (TiO_2).....	.89
Alumina (Al_2O_3)	24.74
Moisture	8.14
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Clay base and sand.....	91.37
Ferrous oxide (FeO).....	2.41
Ferric oxide (Fe_2O_3).....	.15
Lime (CaO)70
Magnesia (MgO)	1.20
Potash (K_2O)	3.40
Soda (Na_2O)90
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Fluxes	8.85
<hr/>	
Total	100.22

The stratum of clay runs from three to four feet thick, and the analysis shows that it will make a high grade of vitrified hollow wares, such as sewer pipe, conduits, fire-proofing, etc. It can be readily and cheaply mined in connection with the coal. The under-clay, No. 16, is said to be of good grade, but as the sump was filled with water, no samples of it were obtainable. The shaft is located within 75 feet of the E. & I. Railway, and, with clays and fuel both present, offers a good site for a clay industry.

One mile east of Buckskin, on the side of the Lynnvile road, southeast quarter of section 27 (3 S., 9 W.), a good quality of soft drab, clayey shale outcrops in a number of places on the John Mayhall farm. The exposures are two feet thick, with bottom hidden, and are overlain with two to four feet of yellow loess clay. The shale is of the character known locally as soapstone, and can be burned into a variety of wares. The same kind of shale outcrops in the roadside gullies in a number of places farther east on the same road, and evidently occurs close to the surface over a wide area.

At Francisco, a station on the Southern Railway, in the north-east quarter of 19 (2 S., 9 W.), drain and roofing tile are made from the surface yellow loess clay, 12 feet thick, by Stormont Bros. The clay has been used without pugging or pulverizing, being passed directly into a Little Wonder tile and brick machine. The wares are nevertheless close-grained and durable. With the

proper preparation of the clay, they would be as good as any made in the State. Beneath the clay occurs a bed of shale 15 or more feet in thickness, but it has not been put to use.

• • •

In ranges 10 to 14 west the only coals mined are at Princeton and Fort Branch. At the former place the Oswald mine, opened in 1895, is located about a mile northwest of the Court House, in the northeast quarter of section 12 (2 S., 11 W.). In its shaft the first rash coal, 10 inches thick, was found, at a depth of 81 feet. Beneath this was seven feet of under-clay, the upper half of which is of excellent quality for terra cotta and similar products. At a depth of 277 feet the first workable vein, coal VII?, three feet seven inches thick, was encountered. Above it was 40 feet of shale the upper 18 of which was of a gray sandy character, and showed a very marked, finely laminated structure, the laminæ being alternately light and dark in color. The lower 22 feet, resting directly upon the coal, was a blue, clayey shale, very similar to that forming the roof of the worked seam at the Prospect Hill mine at Vincennes. While rather hard and massive in structure, it possesses the characteristics of a good material for vitrified products. Below the vein of coal was three feet of a tough, plastic under-clay, which appears to possess high refractory properties. The second workable vein, coal V?, now mined, was found at a depth of 430 feet. It is six to seven feet in thickness, and overlies a dark gray shale or under-clay, very hard and difficult to pick. Above the coal is 30 or more feet of a hard gray shale, with a thin layer of limestone intervening in places. The shaft of this mine is by the side of the E. & T. H. and less than 200 yards from the Southern Railway.

Along the bottoms of Indian Creek, three miles east of Princeton, northeast quarter of section 10 (2 S., 10 W.), are outcrops of a vein of coal 14 inches thick, beneath which is an under-clay four feet in thickness. This was used in making fire brick for the cupola furnace of a foundry at Princeton, and locally for the setting of brick in grates, etc. It is said to possess high refractory qualities.

Near Bald Hill, north of Princeton, one and a half miles, is the outcrop of another "rash" vein of coal, whose under-clay, four

feet thick, was used by Dr. Kidd for making fire brick for his kilns. These brick are said to have stood the heat as well as those bought at Freeman's Landing, Virginia, at \$17 per thousand.

One of the more available deposits of shale found near Princeton is just south of the Southern Railway shops, where an exposure has been made by the roadbed of the main line of that railway. This is in the northeast quarter of section 18 (2 S., 10 W.), and but one-third of a mile east of the E. & T. H. Railway. A section to the bottom of the exposure is as follows:

Section near Southern Railway Shops, Princeton.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil	1	6
2. Yellow surface clay.....	11	0
3. Sand rock, rotten, shelly	6	0
4. Gray clayey shale.....	8	0

The surface clay No. 2 is the fine-grained buff or brown loess material so characteristic of the southwestern counties of Indiana. Fine pressed-front brick are being made of it at Huntingburg, Jasper County. It burns to a handsome shade of red and makes a strong and durable brick. An analysis of a sample taken from the site of the above section was made by Dr. Lyons, of the State University, and its composition found to be as follows:

Analysis of Loess Clay from near Southern Shops, Princeton.

	<i>Per Cent.</i>
Silica (SiO ₂)	71.20
Titanium oxide (TiO ₂).....	.88
Alumina (Al ₂ O ₃)	18.56
Water combined	6.30
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Clay base and sand.....	96.94
Ferric oxide (Fe ₂ O ₃).....	1.34
Ferrous oxide (FeO).....	.15
Lime (CaO)14
Magnesia (MgO) .....	.52
Potash (K ₂ O) .....	.32
Soda (Na ₂ O)	1.26
<hr/>	
Fluxes	3.73
<hr/>	
Total	100.67

For a surface clay this shows remarkable purity. While the percentage of free silica is high, that of lime, which is the most common and injurious impurity found in ordinary surface drift clays, is very low.

The shale No. 4 of the section above given is a drab or light gray material, showing occasional scales of mica and containing a rather large percentage of free silica. Its composition, as shown by an analysis by Dr. Lyons, is as follows:

Analysis of Shale from near Southern Shops, Princeton.

	<i>Per Cent.</i>
Silica (SiO_2)	62.04
Titanium oxide (TiO_2).....	1.30
Alumina (Al_2O_3)	18.49
Water combined	6.50
<hr/>	
Clay base and sand.....	87.33
Ferric oxide (Fe_2O_3).....	7.54
Ferrous oxide (FeO).....	.06
Lime (CaO}) .....	.16
Magnesia (MgO}) .....	.91
Potash (K_2O}) .....	.93
Soda (Na_2O)	2.04
<hr/>	
Fluxes	12.64
<hr/>	
Total	99.97

This shows a very close approximation to the standard average of shales used for making paving brick, and as far as such analysis and general appearance go, it is well suited for that purpose. The area covered by this shale deposit comprises 30 or more acres, and its situation is quite favorable for the location of a combination factory for making both pressed front and paving brick.

At two locations in Princeton ordinary soft mud brick are made from the yellow loess clay above mentioned. At the old Kidd yard, in the southwestern part of the city, now operated by W. M. Read, the stratum of loess used is 12 to 14 feet in thickness, the "strongest" clay being near the bottom. About 1,700,000 brick were made at this yard from this loess in 1904.

Beneath the stratum of loess clay is a deep red, siliceous clay, containing in places small geodes and pebbles of quartz and granite, showing that a spur of some glacier has in the past extended

this far south. From this red clay Dr. Kidd, some years ago, made, as an experiment, very hard and durable brick, which did not shrink, and which, in the absence of shale brick, would serve well as paving material.

At the Mitchell brick yard, in the northwest part of the city, near the junction of the two railways, the loess clay is 12 feet thick, and the underlying red till clay four or more feet. The latter is seemingly free from lime impurities, and the upper two or three feet is mixed with the overlying loess. About 1,200,000 brick were made at this yard in 1904.

By the side of a small stream close to the Southern Railway, in the southeast quarter of section 1 (2 S., 11 W.), a few hundred yards west of the Oswald coal shaft, is an exposure of a good quality of clay shale. The thickness or extent of this stratum could not be ascertained on account of the overlying loess clay. The outcrop is in the bed of the stream at the base of a low bluff. The material seems well fitted for many kinds of clay products, and if the cover be found not too heavy, the spot is a most suitable one for the site of a clay industry.

On the land of Robert Mitchell, a mile and a half northwest of Princeton, in the southeast quarter of section 36 (1 S., 11 W.), there occur, along the banks of the stream known as Maumee Creek, a number of outcrops of a soft blue, clayey shale. The shale is overlain, where exposed, with three feet three inches of soil, surface clay and gravel. The thickest outcrop of shale is four feet, with bottom hidden. An occasional small nodule of iron carbonate is visible in the shale bed, but otherwise it is of a high grade and suitable for all kinds of hollow vitrified wares, such as sewer pipe, conduits, hollow building block, flue linings, etc. The exposure is about one-half mile east of the E. & T. H. Railway, with never-failing springs within one-eighth of a mile. A bore sunk for oil on the same farm, about one-half mile to the west, passed through three veins of coal, the lower one of which was six feet ten inches in thickness.

With plentiful fuel in the form of both natural gas and coal, with good railway facilities, and with excellent raw material in the places pointed out, the vicinity of Princeton should, in the near future, furnish sites for several large clay industries.

One-half mile south of Fort Branch, in the southwest quarter

of section 19 (3 S., 10 W.), and 150 yards east of the E. & T. H. Railway, a new shaft has been recently sunk to Coal VI, four feet six inches in thickness, the bottom of the coal being 240 feet below the surface. Coal VII, three feet three inches thick, was struck at a depth of 218 feet. The roof above coal VII is a dark gray, clayey shale, ten feet in thickness. Below VII is a soft gray, unctuous under-clay, two feet thick. This merges into a dark blue, very compact, clayey shale, 15 feet 9 inches thick, which rests directly on the worked vein of coal VI. Below this coal is a foot and a half of a dark, soft, blue, gritless under-clay. All of these clay materials, from the top of the shale above coal VII to the bottom of under-clay below VI, aggregating 29+ feet in vertical thickness, can be utilized in making many kinds of clay wares, such as paving brick, sewer pipe and all kinds of hollow vitrified products. By using the clays, both veins of coal could be mined at the same time. With a railway switch already in place, and with such a variety and thickness of clays with intervening coals, the site is an excellent one for prospective clay manufacturers.

At Oakland City, Owensville and Haubstadt ordinary soft mud brick are made from the yellow loess clay. At Fort Branch drain tile have also been made for 17 years and brick since 1902, a joint clay, three and a half feet thick, being used, after stripping nine inches of loam. The yard at Owensville is near the E. & T. H. station, and produces a fair output of brick of good grade. The yard at Haubstadt is one-half mile west of the town. Here the clay bank is seven feet in depth, and as the lower portion is a little tough, it is necessary to mix material from the upper and lower parts of the bed to produce a brick that will not crack. The output at this yard averages about one-half million per year. At Oakland City six feet of the yellow loess are used, the output in 1904 being 400,000 common brick.

POSEY COUNTY.

The county of Posey occupies the pocket, or extreme southwestern corner of the State. It lies south of Gibson and west of Vanderburgh counties. On the west it is separated from Illinois by the Wabash and on the south from Kentucky by the Ohio River. Its greatest length from north to south is 31 miles, and width from east to west 21 miles, its area being 410 square miles.

The surface rocks of the county are those of the Upper or Barren Coal Measures, the workable veins of the Lower Coal Measures being everywhere 220 or more feet below the surface. As a result, outcrops or exposures of shales and under-clays are seldom met with. The topography of the county consists, for the most part, of river bottom of varying width, terraces or second bottoms and gently rolling uplands. Only along the bluffs of the Ohio and Wabash rivers are hills and ridges of any height. The broad, annually overflowed alluvial plains range up to five miles or more in width, in many places containing numerous ponds and lakes. With the exception of the immediate river bluffs between New Harmony and Grand Chain, the terrace and upland soils of the county rank among the best of southern Indiana, and are famous for their wheat production, while that of the lowlands is as noted for its crops of corn.

The northern portion of the county is drained by Black River and the central portion by Big Creek, both of which flow westward into the Wabash. The southern third drains directly into the Ohio, by way of numerous small streams and inlets.

The county is well supplied with railway facilities. The Mt. Vernon branch of the E. & T. H. Railway enters at its northeastern corner and runs in a south-southwesterly direction to Mt. Vernon, the county seat. The Peoria Division of the Illinois Central, with spur to New Harmony, runs diagonally across the northern third, while the Evansville-St. Louis Division of the L. & N. crosses the southern third from east to west.

The only exposures of shale which were visited in the county were in the east bluff of the Wabash, near the "cut-off," about three-quarters of a mile southwest of New Harmony. Here the shale is exposed in two ledges, separated by a bench about 30 feet in width. At one point, about 100 feet south of the opening of an old drift slope for coal, the total exposure of shale is 104 feet thick. Ten rods farther south the lower bench is 60 feet and the upper bench is 15 feet in thickness. The total length of the exposure is 700 feet, and the shale reaches down to the edge of the water in the cut-off, with bottom hidden. The lower ledge of shale is of a better grade than the upper, being a soft, unctuous, fine-grained material, which was everywhere on its exposed face weathered into small quadrangular blocks, indicative of its supe-



Two views of the Shale Bluff along the Wabash River, one mile southwest of New Harmony, Posey County.

rior quality. About 12 feet below its top is a 15-inch band of iron-stone concretions. The upper ledge of shale is more sandy, and, worked alone, could probably be made only into brick. The lower ledge will make vitrified wares of many kinds, such as sewer pipe, hollow building block, roofing tile, conduits, etc. A railway switch could be easily constructed from the station at New Harmony to the north end of the bluff. Since steamers readily ascend the Wabash River to New Harmony, much of the manufactured material could be shipped by water at low rate. The vein of coal is but 14 to 16 inches thick, and hence not workable, but cheap fuel could be obtained within 35 miles of the site. The location is an excellent one for a large clay industry.

Aside from the shales at New Harmony, the only carboniferous clays from Posey County which have come to my notice were two under-clays taken from a deep bore made for coal on the grounds of the Industrial Brick Co., near the junction of the L. & N. and E. & T. H. Railways at Mt. Vernon. These under-clays were, respectively, three feet and four feet in thickness, and were obtained from beneath two coals, six feet and four feet in thickness, found at depths of 646 feet and 733 feet below the surface. Analyses of the under-clays were made by T. W. Smith of Indianapolis, and their composition found to be as follows:

Analyses of Under-clays from Mt. Vernon.

	<i>Per Cent.</i>	
	<i>3 Ft. Vein.</i>	<i>4 Ft. Vein.</i>
Silica (SiO_2)	78.85	70.72
Alumina (Al_2O_3)	10.06	15.50
Water (combined)	6.08	8.69
Clay base and sand	94.99	94.91
Ferric oxide (Fe_2O_3)	2.25	1.85
Lime (CaO}) .....	.18	.20
Magnesia (MgO)	2.52	2.30
Potash (K_2O}) .....	.03	.08
Soda (Na_2O}) .....	.01	.02
Fluxes	4.99	4.45
Total	99.98	99.36

The clay from the three-foot vein is the higher in silica, and therefore better suited for making refractory clay products and

stoneware. That from the four-foot vein, when mixed with a shale or clay containing five to eight per cent. more fluxes, will be found suitable for the manufacture of vitrified products, such as sewer pipe, paving brick, etc. In another bore made at Mt. Vernon, by Messrs. E. Brown & Son, 42 feet of drab, clayey shale (soapstone) were found just beneath 27 feet of yellow loess clay.

The loess clays are used for brick-making at several points in the county. At Cynthiana brick-making has been carried on for many years, but the only plant now running is that of Redmond & Co., which produces about 700,000 brick and 3,000 to 4,000 rods of drain tile in a year. The maximum depth of their pit is eight feet. To obtain the best consistency, the materials from all parts of the bed, from top to bottom are mixed. Fairchild's Tile & Brick Works, one and a half miles southeast of Poseyville, have been operated for over 30 years. The loess is here less than five feet thick and rather sandy. At New Harmony there has been a small brick industry for many years, the clay coming from alluvium on the upper portion of the flood plain north of the town, at the works of George B. Beal. The pit is eight and a half feet deep; the top 18 inches is a "tender, mealy clay," easy to burn. This is mixed with six and a half to seven feet of tough, waxy yellow clay, more difficult to burn. About 135,000 brick were made in 1904. At Mt. Vernon the yellow loess clay is used to a depth of five or more feet without stripping in making drain tile and common building brick, the output of the latter having been nearly three and a quarter millions in 1904.

VANDELBURGH COUNTY.

Occupying an area of 236 square miles in the southwestern portion of the State is the county of Vanderburgh. It lies east of Posey, south of Gibson and west of Warrick Counties, and on the south is separated from Kentucky by the Ohio River. The extreme length of the county from north to south is $23\frac{1}{2}$ miles, while its greatest width from east to west is 13 miles.

The greater portion of the county is covered by the rocks of the Upper or Barren Coal Measures. Coal VII, the uppermost workable vein of the Lower Coal Measures, occurs close to drainage level along the east edge of the county, but in the central and

western parts is 150 to 240 feet below the surface. The northern part of the county is a fairly level tableland. The Ohio River bottoms, from two to five miles wide, extend along the southern edge, while the broad bottoms of Pigeon Creek and other streams add much to the lowland area. The intermediate broken area is in part rolling, and to a less extent presents rather steep or abrupt slopes. The upland is from 150 to 350 feet above low water in the Ohio.

The northwestern corner of the county is drained by Big Pond Creek and its branches, the central third by Pigeon Creek and numerous tributaries, and the southern portion directly into the Ohio by a number of small streams and bayous.

Evansville, the county seat, is the second city in size in the State, and is especially noted for the number and magnitude of its manufactories. This is largely due to the excellence of its transportation facilities. Occupying an important site on the Ohio River, below interrupting rapids and ice, and near the outlet of the Wabash, Greene and Tennessee rivers, it has an important water communication with the states to the south and west, which has added much to its enterprise and growth. In addition to this, seven railways enter its bounds and furnish direct connection with the leading cities of the United States. These are the E. & T. H. and E. & I., running north and northeast the full length of the county; the Peoria Division of the Illinois Central, northwest; the St. Louis Division of the Southern, east; the Ohio Valley and the Louisville & Nashville, south, and the St. Louis Division of the L. & N., west. Besides these, the Evansville & Princeton traction line runs north and the Newburgh suburban line east, both passing beyond the limits of the county.

Next to transportation, cheap and abundant fuel is the leading factor tending to promote manufacturing interests. Vanderburgh County lies, as we have seen, wholly within the Coal Measures. A four-foot seam of coal V underlies nearly the whole area of the county. Numerous shafts have been sunk to it within the corporate limits of Evansville. These and the mines at Newburgh and Oakland City can furnish a cheap source of power for factories unlimited.

Townships 4 and 5 South, Ranges 10 and 11 West.

Few if any workable exposures of shale or under-clay occur in the northern half of the county. Coal VII, where found, averages about three feet thick, and is underlain by a good bed of under-clay, three to five feet thick, below which usually occurs a stratum of gray, clayey shale, 10 to 30 feet in thickness. Coal VII is, in most places, too thin for profitable mining, but if it and the underlying clays were worked together and the latter put to use it would undoubtedly prove a paying enterprise.

At Inglefield, in the northwest half of section 8 (5 S., 10 W.), a bore shows coal VII, 18 inches thick, at a depth of 209 feet, to be underlain with four feet of under-clay and 38 feet of gray, clayey shale. At the Graff place, close to the Illinois Central Railway, in the northeast of 22 (5 S., 11 W.), is said to be a surface shale deposit 30 feet thick, but I have seen no samples of the material.

On the land of C. Lobshire, near the line of the E. & P. Traction Co., in the southwest quarter of section 31 (5 S., 10 W.), is a limestone quarry which has been operated for 50 years for macadam and other purposes. The limestone lies in two ledges, each averaging six feet in thickness, and between the two is a stratum of soft gray shale, two and a half feet thick. Above the upper ledge of limestone is a cover of sandstone, shale and surface clay, 8 to 20 feet in thickness.

About 200 feet south of the quarry is an outcrop of light gray, clayey shale, in very thin layers, which is locally called a potters' clay, and could doubtless be used for stoneware. It is a soft, gritless, unctuous material, about 18 inches thick, and overlain with six to eight feet of loess clay. Several tons of the potters' clay were formerly shipped to some clay factory at Evansville, but information as to what one or the character of the ware made was not obtainable.

Township 6 and Part of 7 South, Ranges 10 and 11 and Part of 9 West.

This area, comprising the southern half of the county, contains practically all the working mines and the principal available clay deposits.



Shale Pit of Evansville Pressed Brick Co., Evansville, Vanderburgh Co.



Shale Pit of Standard Brick Co., near Evansville.

The Evansville Pressed Brick Company has, since 1890, been using, on a large scale, the shales found in the immediate vicinity of Evansville in making vitrified brick for street paving purposes. For some time under-clays from Lincoln City, Spencer County, and other points were used. Wishing a cheaper material, the company began experimenting with the shales found along the low bluffs of Pigeon Creek, and finding them highly suitable for their purpose, purchased a tract of land in the southeast of the northeast of section 24 (6 S., 11 W.). The bed from which the shale is at present obtained is on this land, just at the outskirts of the city, and three-quarters of a mile from their plant, necessitating the hauling of the material in wagons for that distance. A section at the pit in August, 1904, showed the presence of the following strata:

Section of Clay Pit of Evansville Pressed Brick Company.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil and yellow loess clay.....	11	0
2. Drab to blue clayey shale.....	20	6
3. Gray sandy shale.....	2	9
4. Blue clayey shale.....	3+	0

About two feet above the No. 3 shale is a thin layer of kidney iron ore. Aside from it, everything, from the grass roots down, is used, being blasted down and loaded directly into the wagons. Six of these, hauling one and a half cubic yards each, make nine trips daily between the pit and plant. About 75 cubic yards are ground daily, the remainder being stored in sheds. The expense for teams is \$21 per day, much of which could be saved by putting in a railway spur or a tramway between the plant and clay pit.

Shales Nos. 2 and 4 are of good quality, being composed of that soft, close-textured, smooth variety of clay shale locally known as "soapstone." The gray, sandy shale, No. 3, contains just about enough surplus silica to form a mixture well suited for making a vitrified brick at once strong, tough and practically non-absorbent, and one of which many hundred millions have been sold within the past fourteen years. A daily average of 23,000 brick were made in 1904, the most of which were shipped to East St. Louis and Belleville, Ill. The company owns 30 acres of land surrounding the pit, and have worked but about two acres of it in 12 years.

An analysis of the mixture of surface clay and shale as it goes into the brick was made by Dr. Noyes, and its composition found to be as follows:

Analysis of Material Used in Making Paving Brick by the Evansville Pressed Brick Company.

	<i>Per Cent.</i>
Silica (SiO_2)	65.87
Titanium oxide (TiO_2).....	1.10
Alumina (Al_2O_3)	14.66
Water combined	4.59
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Clay base and sand.....	86.22
Ferric oxide (Fe_2O_3)	6.23
Ferrous oxide (FeO).....	1.37
Lime (CaO)39
Magnesia (MgO)	1.54
Potash (K_2O)	2.66
Soda (Na_2O)	1.31
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Fluxes	13.50
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Total	99.72

This proves the mixture well adapted for the uses to which it is put, as the composition is very close to that of the average composition of the Ohio shales used for such purpose.

This deposit of shale, both drab and blue, covers a large area north and northwest of Evansville, and outcrops in a number of places along Pigeon Creek and its tributaries. An especially large and valuable bed of it occurs in the southeast quarter of section 8 (6 S., 10 W.), about three-quarters of a mile east of Rose Hill cemetery. Along the borders of the stream known as Locust Lick it is especially noticeable. On the farm of Rudolph Fistle, in the northeast quarter of section 14 (6 S., 11 W.), the drab variety is exposed to a thickness of 11 feet, and on the land of Jenner & Nugent, one-half mile farther east (northeast of southwest of 13) is a bold bluff, 30 feet in height, which is equal in quality to that worked by the Evansville Pressed Brick Co. The exposures are mainly of the drab color, due to their being weathered and also to being saturated by the leachings of the overlying loess.

At the Crescent City Park, on the east bank of Pigeon Creek, southeast quarter of section 24 (6 S., 11 W.), a bore was put down a number of years ago which resulted in a strong flow of artesian

water. The record of that bore for the first 130 feet was as follows:

Partial Section of Bore in Crescent City Park.

	<i>Fect.</i>	<i>Inches.</i>
1. Soil and surface clay.....	7	0
2. Soapstone	24	0
3. Gray sandstone	2	6
4. Soapstone and shale.....	37	6
5. Gray sandstone	1	0
6. Coal	1	6
7. Under-clay	6	0
8. Gray shale	51	0

This shows an inexhaustible supply of excellent clay within the city limits, for the "soapstone," of which more than 60 feet were gone through, is the best material known for paving and hollow brick, sewer pipe, pressed-front brick and many kindred products.

Across Pigeon Creek, west of this, near Babytown, is a high piece of ground, known as "Law Hill," northeast of southeast of 23 (6 S., 11 W.), on the western slope of which Adam Helfrich had, for a number of years, one of the largest brick yards in the vicinity of Evansville. This yard has been recently acquired by the Standard Brick Company, and the plant equipped with new machinery for making a dry-pressed brick from shale. The shale outcrops a few rods back of the kilns, and a well, 34 feet deep, in the yard, did not reach the bottom of it. Mr. Helfrich tested it to some extent in making ordinary brick, and stated that it was far superior to the surface clay for that purpose, but as it required different machinery, its use was not continued by him. He had stripped the surface loess from seven or eight acres on the slope of the hill and left the underlying shale in good condition for the new company to work. At the pit the surface loess clay is eight feet thick and the exposure of shale 18 feet, with bottom hidden. The upper eight feet is rather high in silica, and shows some scales of mica, while the lower portion is a tough, smooth, fine-grained, plastic material. A mixture of the two makes an even-grained, hard and durable dry-pressed brick, dark cherry red in color. These, while green, weigh six and a half, and when burned five and a half pounds. The company owns 27 acres, including a large portion of Law Hill. They began making the dry-pressed brick at the rate of 20,000 per day in June, 1904, and were selling

them for ordinary building purposes at \$5.25 per thousand delivered. The shale is carted to the dry pans, but a tramway will soon be put in and a storage shed, 150x60 feet, built, which will hold clay enough for a million and a half brick. The plant is well equipped, and, with an abundance of excellent raw material at hand, it will undoubtedly prove a paying investment.

Outcrops on the east side of Law Hill and on Wheeler's Hill, to the northeast, showed that almost the whole of the east half of section 23 (6 S., 11 W.), is underlain with a good quality of shale. These two hills are less than one-third of a mile from a railway, and the shale at both places can be secured by easy stripping. These deposits contain enough of it to furnish paving brick for all Southern Indiana for a hundred years. It can also be made into dry pressed-front brick, and, if carefully selected, into sewer pipe and other hollow wares.

At the First Avenue Coal Mine, located near Pigeon Creek, in the western part of the city, the under-clay beneath the worked seam is a very dark, plastic material, which could be utilized in the making of terra cotta. It contains some pyrites, which can be eliminated to a large extent by exposure to the atmosphere. The shale overlying the coal contains too much bitumen to be of value for vitrified products.

The yellow surface loess clay of Vanderburgh County is, like most of that found south of the drift area, suitable in the highest degree for ordinary brick and will make pressed front brick of a fair quality. About a dozen yards were operated in 1904, within a radius of two miles of the Court House at Evansville.* A number of these were small establishments, where the output was moulded by hand. Such competition could but result in very low prices, and the bricks were, in August, being delivered within the city at \$5.25 per thousand.

A partial analysis of a sample of this yellow surface clay from the brick yard of Wm. Schnute, in the northeastern part of the city of Evansville, was made for former State Geologist Gorby by Dr. J. N. Hurty, and its principal constituents found to be as follows:

*See statistical table near end of paper.

Partial Analysis of Yellow-loess Clay from Evansville.

	<i>Per Cent.</i>
Silica (SiO_2)	77.930
Alumina (Al_2O_3)	12.160
<hr/>	
Clay base and sand.....	90.090
Magnesia (MgO}) .....	.571
Lime (CaO}) .....	.347
Ferric oxide (Fe_2O_3).....	4.480
<hr/>	
Fluxes	5.398
Moisture and volatile.....	4.501

This shows the loess to be higher in silica and lower in alumina than that found at Princeton. It is, however, a clay of high purity, and with a composition approaching closely some of the under-clays of the coal seams. The low per cent. of iron oxide is surprising, as the color of the clay would denote much more.

WARRICK COUNTY.

Warrick County lies along the southern boundary and close to the southwestern corner of the State. The Ohio River runs along part of its southern border. It is situated east of Vanderburgh, south of Pike and the southeastern corner of Gibson, and west and partly north of Spencer county. Its extreme length from north to south is $25\frac{1}{2}$ miles, and width from east to west, $24\frac{1}{2}$ miles, its area being 397 square miles.

The entire surface of the county is covered with the rocks of the Coal Measures. The topography is for the most part rolling, but rises into a high knobby ridge in the northern part of the county, where the waters draining south divide from those draining northwest. A noticeably high ridge runs down the western edge of Pigeon Township, in the northeast corner. Isolated hills of some prominence also occur near the center in the southeastern part of Boone township and close to the Ohio River in the northeastern part of Anderson township. The latter appear to owe their existence in part to one of the Coal Measure limestones. The land is for the most part well adapted to cultivation, large quantities of wheat, corn and hay being annually produced and shipped to markets on the Ohio River. Tobacco is also one of the staple products grown.

The northwestern part of the county is drained into Big Creek, one of the tributaries of Patoka River. Pigeon Creek drains the western third of the county, while Little Pigeon, which forms the greater part of the eastern and southern boundaries, with its numerous branches drains the eastern half. The only other stream of any size is Cypress Creek, which flows from the center south into the Ohio River.

The railway facilities of the county are poor. The Evansville branch of the Southern Railway runs east and west across the southern half, while the E. & I. cuts across a small area in the extreme northwestern corner. A suburban railway between Newburgh on the Ohio River and Evansville is the only other outlet. The north half, with its rich mineral resources is thus distant from means of transportation.

Coal VII occurs close to the surface in the western third of the county. Above it is a stratum of drab to blue clay shale; while below it there is usually, though not always, a bed of good under-clay, the latter in places directly overlying a bed of shale. In places a thin vein of coal VIIb occurs below coal VII, and is often separated from the latter only by under-clays. Coal V is the main vein mined in the county, but its under-clay, here as elsewhere, is of inferior grade. In the northeastern part of the county, coal IV occurs, 50 to 75 feet below V, and is often overlain with a good bed of clay shale and underlain with a fair quality of under-clay. From 15 to 40 feet below IV is IIIb, beneath which is a bed of good under-clay suitable for stoneware and many other products.

Township 4 and Part of 3 South, Ranges 6, 7, 8 and 9 West.

This area of 171 square miles comprises the northern third of the county, and is, for the most part, distant from railways, the E. & I. crossing its western border.

Just northwest of Selvin, on the Taylor farm, southeast quarter 31 (3 S., 6 W.), coal IV, two feet thick, is overlain with ten feet or more of soft, gritless shale, suitable for many kinds of clay products.

In the vicinity of Scalesville, southeast corner of 32 (3 S., 7 W.), coal VI, 10 inches thick, is overlain with 10 or more feet

of drab to blue clay shale of good workable quality, and underlain with three feet of dark shaly fire-clay. Below coal VI, about 34 feet, is coal V, nearly five feet in thickness.

Below coal IIIb, in the vicinity of Folsomville, northwest quarter section 35 (4 S., 7 W.), occurs an under-clay four or more feet thick. This, where exposed in the slopes, has partially weathered into a high grade potters' clay which, according to O. C. Lee, superintendent of the Uhl Pottery at Evansville, is one of the best in the State.

Near Lynnville, in the northern part of Hart Township, coal VII occurs close to the surface and has above it in many places a thick bed of soft fine-grained, drab to blue clay shale. Just northwest of the town by the roadside and on the land of A. J. McKinney, southeast quarter of section 33 (3 S., 8 W.), are exposures of this shale six to eight feet thick with bottom hidden, and with two to four feet of yellow loess clay above. On the level land, two to four feet of sandstone lie between the surface clay and shale. This is close to the survey of the Evansville Division of the Southern Indiana Railway. Another good exposure occurs in the north part of the town, northeast quarter of section 4 (4 S., 8 W.).

On the D. W. Thompson farm, one-half mile east of Lynnville, northeast quarter of section 3 (4 S., 8 W.) the following section is exposed:

Section on Thompson Land, near Lynnville.

	<i>Feet.</i>	<i>Inches.</i>
1. Yellow loess clay.....	3	6
2. Drab clayey shale.....	2	6
3. Black sheety shale.....	1	0
4. Coal VII	3	1
5. Under-clay	2	9
6. Coal VIb	2	6
7. Under-clay	3+	0

The shale No. 2 and the under-clays 5 and 7 can be made into many kinds of clay products, the under-clay No. 5 being especially suited for terra cotta and hollow building block. By mining it in connection with the coals, both veins of the latter could be readily utilized.

At the McGladden mine, three-quarters of a mile southeast of Lynnville, the gray clayey shale above coal VII is 8+ feet thick,

and of good quality for clay wares; while between coals VII and VIb is three feet of under-clay.

Near Big Creek, by the side of the Boonville road, two and three-quarter miles south of Lynnville, occur a number of fine outcrops of the gray clayey shale overlying coal VII. These exposures are three to eight feet thick, with bottom hidden, and are overlain with one to four feet of yellow loess clay. The best outcrops are in the northeast quarter of 15 and the north half of 22 (4 S., 8 W.), on the French and Graham farms. The shale is very fine grained, soft and unctuous and evidently occurs close to the surface over a wide area to the west. If the Walsh Railway is ever built this shale will prove a valuable material for many kinds of vitrified wares.

In Greer township (4 S.; 9 W.), coal VII, from 10 to 75 feet below the surface, probably reaches its maximum thickness in southern Indiana, ranging from four and a half to six feet. Above the coal is one to two inches of bone coal, then clay shale, with thin bands of iron ore for a thickness of 30 or more feet. This shale is, for the most part, a good clay-working material.

On the Miller farm, in the northeast quarter of section 13, the coal has been struck in wells at a depth of about 18 feet, with the gray clay shale forming the greater part of the cover. At the Thompson mine, southeast quarter of 16, the coal is 26 feet below the surface, with a good bed of shale above. This latter point is a mile and a half east of the E. & I. Railway.

Township 5 South, Ranges 7, 8, 9 and Part of 6 West.

This area of 124 square miles comprises the central third of the county. The Southern Railway runs east and west across its greater portion. Coal VII covers the western third, while coals V, IV and IIIb form the surface veins of the eastern half.

The coal mined in the vicinity of Boonville is No. V, and the accompanying under-clays and shales are of little value.

By the side of the Evansville Division of the Southern Railway one mile northeast of Boonville, is an abandoned shaft of the Big Four Coal Co., in which the following section is exposed:

Section at Old Shaft of Big Four Coal Company.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil and surface clay.....	12	0
2. Shelly sand rock, with numerous small iron kidneys	3	0
3. Dark shaly fossiliferous limestone.....	13	0
4. Black sheety shale.....	4	0
5. Coal V	6	4
6. Under-clay	2+	0

No one of these is suitable for manufacturing. The under-clay, the thickness of which I was not able to determine, is very hard, of a greenish-gray tint, and contains so large a percentage of alkali fluxes as to render it worthless. Brick made from it were tested by L. Klostermier, of Boonville, in the floor and flue arches of clamp kilns. In a short time they began to swell up, then the surface melted and flowed like slag, and finally the whole body of the brick became black, porous and lava-like in appearance.

Three-fourths of a mile northeast of this old shaft is the worked mine of the T. D. Scales Coal Co., northeast quarter section 25 (5 S., 8 W.). Here No. V coal, seven feet thick, is mined at a depth of 40 feet. The air shaft slope, 136 feet in length, starts in the black shale above the coal and goes up at an angle of about 40 degrees. Just above the black shale is a band of iron carbonate about one foot thick, and above this a light clay shale 10 to 12 feet in thickness. Overlying the shale is 10 to 12 feet of soft sandstone, then 13 feet of yellow loess clay which forms the surface.

At the brick yards of L. Klostermier and the Industrial Brick Works, in the northern part of the town of Boonville, north half of section 26 (5 S., 8 W.), an exposure of soft gray unctuous soapstone has been made by the removal of the yellow surface clay. This stratum has been proven, by boring, to be from seven to 30 feet in thickness. On the yard at the Industrial Works the following section is exposed:

	<i>Feet.</i>	<i>Inches.</i>
1. Soil	1	3
2. Yellow loess clay	6	9
3. Soapstone with layer of iron kidneys in upper 6 inches	10	0
4. Sandstone	??	0

No use has been made of this soapstone. Mr. Klostermier has ground some of it and attempted to make drain tile, but it clogged the machine too badly. Mixed with a more siliceous material, as the overlying surface clay, it will undoubtedly prove suitable for vitrified products and hollow brick. Aside from the iron concretions found in its upper part, the stratum is remarkably pure and homogeneous throughout. In a well on the Wm. Adams lot in Boonville this shale is said to have been 20 feet thick.

At the Pace & Ingle farms, along Squaw Creek, northwest of Boonville, west half of section 3 (5 S., 8 W.), coal VII, about three feet thick, is overlain with eight to 12 feet of gray, clay workable shale. The same coal and shale outcrop in various places in sections 4, 5, 6, 8 and 18 (5 S., 8 W.).

At Millersburg, in the southeast quarter of 11 (5 S., 9 W.), coal VII has 12 to 14 feet of overlying clay shale and five to seven feet of under-clay and gray shale beneath.

At the Chandler shaft, in the southwest quarter of 36 (5 S., 9 W.), the following section is reported:

Section at Chandler Shaft.

	<i>Feet.</i>	<i>Inches.</i>	<i>Feet.</i>	<i>Inches.</i>
1. Clay shale	16	0	16	0
2. Coal VII	2	6	18	6
3. Under-clay	2	0	20	6
4. Blue dark limestone with crinoid stems	9	5	29	11
5. Clay shale	4	0	33	11
6. Hard sandstone	3	0	36	11
7. Light clay shale.....	0	8	37	7
8. Sandy shale	11	10	49	5
9. Sandstone	5	3	54	8
10. Gray clayey shale.....	10	5	65	1
11. Dark clayey shale.....	2	1	67	2
12. Gray shale with plates of sand- stone	34	0	101	2
13. Black sheety shale.....	1	0	102	2
14. Shaly clod with large boulders...	0	8	102	10
15. Coal V	4	2	107	0
16. Under-clay	4	0	111	0
17. Sandy shale, iron nodules.....	5	0	116	0

Of these Nos. 1, 3, 5, 7, 10, 11 and part of 12, aggregating 50 feet in vertical thickness, can be worked into clay products.

*Township 6 and Part of 7 South, Ranges 8 and Parts of 9
and 7 West.*

This area of 102 square miles, comprises the southern third of the county. About 10 miles of its southern border lies along the Ohio River.

The Southern Railway cuts across its northwestern corner and the E. & N. suburban line runs as far as Newburgh in the southwestern corner.

Coal VII, with its accompanying shales and under-clays, covers the greater part of the western half and also occurs in the higher hills and ridges north of Yankeetown. Coal V is the principal vein mined. At the Eph. Whitmer mine, in the northeast quarter of 1 (6 S., 8 W.), 18 feet of gray clay shale overlies the worked vein V, here five and a half feet thick. The same bed of shale, 20 or more feet thick, occurs over coal V, in the southeast quarter of 35 (6 S., 8 W.), and at the Herring slope in the northwest quarter of 14 (7 S., 8 W.).

On the west side and close to the mouth of Cypress Creek, in the northeast quarter of section 12 (7 S., 9 W.), is an exposure of soft gray clayey shale, 10 or more feet in thickness. This is on the north bank of the Ohio, on land belonging to Dr. Wilson, of Yankeetown. If utilized, the wares could be shipped by water. It can be burned into a variety of vitrified products. Coal V, four and a half feet in thickness, lies about 76 feet beneath the shale. The proposed Evansville and Rockport trolley line passes over the shale deposit.

The vicinity of Newburgh offers special attractions to persons seeking sites for clay working industries. It is on the Ohio River and the suburban line from Evansville, so that shipments can be made either by water or rail. Raw material of good quality is abundant and a four foot vein of coal V is mined at 90 to 120 feet.

One and a half miles north of the town, southeast quarter of 27 (6 S., 9 W.), the soft drab clay shale overlying coal VII outcrops in the road, with three to five feet of yellow loess above. At this point a boring 15 feet deep did not reach the bottom of the shale stratum. A 69 acre tract of land adjoining the outcrop was purchased in 1904 by the Star Brick and Tile Co., of New-

burgh. On this tract, about an eighth of a mile southeast of the outcrops in the road, a test pit four feet in diameter and 10 feet deep, was sunk in the shale without reaching bottom. In the cemetery just south the top of the shale occurs three to four feet below the surface, and it evidently underlies a large area north and northwest of Newburgh.

Samples of both the surface loess and the shale were burned into dry pressed front brick, which were first class in every respect. They were very hard, with good corners and edges, a smooth surface and a clear metallic ring. The brick made from the shale were a little smaller and darker colored than those from the loess. Samples of vitrified street brick from the shale have also been made, which were dense, strong and apparently non-absorbent. The shale can also be made into sewer pipe and different kinds of hollow vitrified wares. From a mixture of equal parts of the shale and loess a good quality of clay shingle is being made by the Star Company.

The Warrick Roofing Tile Co., of Newburgh, is using a gray plastic surface clay in making a roofing tile. This clay, seven feet thick, is found in their pit in the north side of the town and is carted to the plant. It is free from grit and otherwise very pure, and burns to a handsome light cherry red tile which sell at \$6.00 per square. Building brick and drain tile are also manufactured by the company from the same clay.

At the shaft of the Evansville and Ohio River Coal Co., one-half mile west of Newburgh, coal V, four feet thick, is mined at a depth of 128 feet. Coal VII occurs at a depth of 47 feet, with two and a half feet of under-clay beneath.

By the side of the suburban railway, two miles west of Newburgh, in the southwest quarter of section 32 (6 S., 9 W.), the Ohio River Coal Company has just completed a shaft to coal IV, five feet nine inches thick, 253 feet below the surface. As this is the only shaft sunk to coal IV south of Linton, Greene County, I have thought best to incorporate its full log, for the use of future prospectors who wish to develop that vein in southern Indiana. The record was obtained for me by State Mine Inspector Epperson, who visited the shaft several times while it was being sunk, and brought in samples of the strata passed through.

Section of Epworth Mine Shaft west of Newburgh, Warrick Co.

	<i>Feet.</i>	<i>Inches.</i>	<i>Feet.</i>	<i>Inches.</i>
1. Surface	8	0	8	0
2. Sand, loose, rather dry.....	42	0	50	0
3. Soft gray mud.....	5	0	55	0
4. Sand	7	0	62	0
5. Sand rock	12	0	74	0
6. Soft gray clayey shale.....	10	0	84	0
7. Hard sandy shale.....	1	0	85	0
8. Soft gray to blue clayey shale with occasional ironstone nod- ules	16	6	101	6
9. Sandy shale	2	0	103	6
10. Dark blue clay shale.....	10	0	113	6
11. Flint rock		6	114	0
12. Dark gray clayey shale.....	10	6	124	6
13. Black bituminous shale.....	1	6	126	0
14. Gray clayey shale.....	3	0	129	0
15. Black bituminous shale.....	1	0	130	0
16. Coal V	3	7	133	7
17. Under-clay, light bluish gray....	4	0	137	7
18. Limestone	6	0	143	7
19. Hard dark blue shale.....	2	6	146	1
20. Sand rock	4	0	150	1
21. Dark gray clayey shale.....	41	6	191	7
22. Light gray clayey shale.....	24	0	215	7
23. Black shale		6	216	1
24. Hard rock		4	216	5
25. Coal IVb	1	10	218	3
26. Under-clay	1	0	219	3
27. Gray clay shale.....	2	0	221	3
28. Gray sandy shale.....	15	0	236	3
29. Hard rock	1	0	237	3
30. Hard gray sandy shale.....	3	0	240	3
31. Hard gray shale.....	7	0	247	3
32. Coal IV	5	9	253	0

The section is remarkable for the number and variety of the different clay shales passed through. Nos. 6, 8, 10, 12, 19, 21 and 22, aggregating no less than 115 of the total of 253 feet of the section are composed of very fine grained shales which, were it practicable, could be made into the best of vitrified products.

The yellow loess covers a large portion of Warrick County, and at several yards is utilized for soft mud brick making. Those at Newburgh and Boonville have already been mentioned. Others at Lynnvile and Elberfeld use from five to seven feet of the loess, little or no stripping being necessary at either place.

SPENCER COUNTY.

This is a county of irregular elongate shape, situated in the southwestern part of the State on the Ohio River. On the north it is bordered by Dubois and Warrick counties, on the west by Warrick and on the east by Perry County. Since the eastern border is formed mainly by Anderson Creek, the western by Little Pigeon River and the southern by the Ohio River, the outlines of the county are of necessity very uneven. The maximum length from the northeastern corner to the Warrick County line at the southwestern corner is $34\frac{1}{2}$ miles, and the greatest width from east to west, 21 miles; its area being 406 square miles.

The surface rocks of the county are, for the most part, those of the Coal Measures, the Mansfield Sandstone outcropping only along Anderson Creek on the eastern border. The eastern part of the county is very rough, the surface being broken into high hills and sharp ridges, with narrow intervening valleys. The hills rise from 50 to 240 or more feet, with precipitous walls and overhanging cliffs. Farther west the hills are lower, with gentle slopes running off into broad valleys. To the west and south along Pigeon Creek and the Ohio River there is a wide stretch of bottom land, varying in width from a mile to six miles or more. From the Ohio River at Rockport to a point some eight miles west is a triangular body of hilly uplands, the hills rising from 30 to 60 feet above the surrounding plains. A large part of the western and southern portions of the county is covered with a soil of great fertility. The leading crops are corn, hay, tobacco and potatoes.

The extreme eastern part of the county is drained by Anderson River, a meandering stream with a narrow valley, enclosed between high and broken banks. The central and southern portions drain into the Ohio through Crooked, Little Sandy, Big Sandy, Honey and Garrett's creeks. The level lands of the northwestern and southwestern portions are drained by a number of ditches and small streams leading off to the west into Pigeon Creek and to the south into the Ohio.

The Rockport Branch of the St. Louis Division of the Southern Railway crosses the county from north to south, passing through Lincoln City and Chrisney, and ending at Rockport. The Cannel-

ton Branch of the same road, crosses the county from northwest to southeast, from Lincoln City to Anderson River, one mile above Maxville. The Evansville Branch of the Southern Railway runs east and west across the northern half of township 5 south, 6 west. The Ohio River on the south also affords a splendid outlet for commerce to points east and west.

Coal IV, the uppermost vein occurring in the county, is found only in the Knobs north of Rockport, and west of Centreville. It is often overlain with a good bed of clay shale. Coal III, which is the most persistent and the main vein worked in the county, is usually overlain with a thin bed of coal IIIa, and one or two strata of good clay working shales. These shales form the surface in a number of localities. The under-clay beneath IIIa is also of good quality for clay wares, but that beneath III often contains too much sulphur and copperas.

Township 4 South, Ranges 4 and 5 West.

This area of 72 square miles lies along the northern border of the county and the western third is crossed from north to south by the Evansville Branch of the Southern Railway. Coal III occurs near the surface over 4 south, 5 west, and the western half of 4 south, 4 west.

The main clay working materials in 4 south, 4 west, are a bed of under-clay and shale immediately below a thin vein of coal IIIa. A good exposure of this under-clay and shale occurs on the southwest quarter of section 6, the strata showing as follows:

Section of Hill in Southwest Quarter of Section 6 (4 S., 4 W.).

	<i>Feet.</i>	<i>Inches.</i>
1. Surface	4	6
2. Thin bedded sandstone	1	0
3. Coal IIIa	0	5
4. Under-clay	2	0
5. Drab clayey shale.....	15	0

The same coal and under-clay outcrop on the Metzger place in the southwest quarter of 5; on the Altmeyer farm in the northeast quarter of 5; on a hill near the center of 16, and on the Schue farm in the northwest quarter of 30. The section near the center of 16 is as follows:

Section near the center of Section 16 (4 S., 4 W.).

	<i>Feet.</i>	<i>Inches.</i>	<i>Feet.</i>	<i>Inches.</i>
1. Soil	5	0	5	0
2. Sandstone and shale	4	0	9	0
3. Coal IIIa	0	6	9	6
4. Under-clay	2	0	11	6
5. Drab clayey shale.....	13+	0	24	6

At the Schue place the under-clay is four feet and the shale 15 feet in thickness.

In the southwest quarter of section 27 (4 S., 5 W.), coal IIIa is underlain with one foot of clay and 14 feet of shale. A drilled well at the Mariah Hill Marble Works is reported to have passed through 78 feet of "fire clay" below coal IIIa. This was doubtless mostly clay shale. At the J. R. Thorp farm in the northwest of 22 (4 S., 5 W.), coal IIIa is two and a half feet thick with under-clay five feet thick and then shale below. The coal has been worked by drift slopes quite extensively near Dale Station in section 16, and is everywhere underlain with the clay and shale.

Township 5 South, Ranges 4, 5 and Parts of 3 and 6 West.

This area of about 100 square miles lies a little north of the center, and is well supplied with transportation facilities. Coals IIIa, III and II occur, with the shales between IIIa and III and the under-clays of both coals forming the principal clay working materials. One of the best exposures of shale is in the cut on the Cannelton branch of the Southern Railway a mile and a quarter southeast of Lincoln City. This is several hundred feet in length and 30 feet deep, a section showing the following strata:

Section at Railway Cut Southeast of Lincoln City.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil and surface clay.....	4	0
2. Light drab clayey shale.....	10	0
3. Concretions of kidney iron ore.....	0	4
4. Dark gray clayey shale.....	16	0

With the exception of the four inch band of iron ore this deposit of shale is free from impurities. It is soft, gritless, and weathers in places into quadrangular pieces an inch or two in size, indicative of its superior grade. An analysis of a mixture of the



Searles Cut through Shale on Rockport Branch of Southern
Railway, two miles southwest of Lincoln
City, Spencer County.



Clay and Shale Pit, just north of Cannelton, Perry County,
operated by the Clark Sewer Pipe Co.
(See p. 334.)

two colors of this shale, made by Dr. Noyes, shows the following composition:

Analysis of Shale from Cut on Cannelton Branch of Southern Railway.

	<i>Per Cent.</i>
Silica (SiO_2)	56.68
Titanium oxide (TiO_2) .....	.90
Alumina (Al_2O_3)	20.33
Water combined	6.54
<hr/>	
Clay base and sand	84.45
Ferric oxide (Fe_2O_3)	4.35
Ferrous oxide (FeO)	3.69
Lime (CaO}) .....	.57
Magnesia (MgO)	2.04
Potash (K_2O)	3.15
Soda (Na_2O}) .....	.63
<hr/>	
Fluxes	14.43
Carbon dioxide (CO_2) .....	.47
<hr/>	
Total	99.35

This shows but a slight variation from the standard average composition of shales suitable for vitrified products, and proves the chemical fitness of this deposit for that use.

This stratum of shale overlies a large area south and southwest of Lincoln City. Exposures from 15 to 30 feet in thickness are made in it by the Rockport branch of the Southern Railway at Eliza cut between Lincoln City and Rockport Junction, and at the Searles cut, one half mile south of the latter point. Other outcrops are found on the Cannelton branch between the big cut above mentioned and Buffaloville, and between the stations of Lamars and Evaston.

At the Searles cut, 300 feet long, the shale is 15 feet thick, with four feet of yellow surface clay above. The lower five feet of shale is dark grayish blue, and contains more silica than the upper drab stratum. A layer of ironstone nodules separates the two, as at the cut on the Cannelton branch. The land adjoining the Searles cut on the west belongs to Hon. F. B. Posey, of Evansville. A bore made on his land near the north end of the cut disclosed the following section:

Section of Bore on Land of F. B. Posey, southwest of Lincoln City.

	<i>Feet.</i>	<i>Inches.</i>
1. Dark gray to blue shale.....	8	0
2. Coal IIIa	0	3
3. Under-clay	7	0
4. Hard gray limestone	8	0
5. Black shale	1	0
6. Under-clay	6	0
7. Limestone	7	0
8. Blue clay shale	6	0

Coal III was not reached at this point unless it be represented by the black shale No. 5. The under-clays 3 and 6 will be found suitable for all kinds of hollow vitrified wares.

On the land of John S. Meyer, one mile southeast of Lincoln City, northeast of southeast of 5 (5 S., 5 W.), is the old Henry Shafer mine, now operated by the Lincoln Mining Company. An excellent grade of coal III is here mined, the coal averaging about three feet eight inches in thickness and overlying a bed of dark gray, fine grained, unctuous under-clay, five to eight feet in thickness. The coal is now mined by a slope shaft and, where struck, lies 14 feet below the surface. From one to two feet of the clay have to be removed for height. One thousand or more carloads of it were shipped in 1891 and 1892 to Evansville and made into vitrified brick by Lant, Morris & Co. When this firm discovered and began to utilize the shale near Evansville, the shipping of the under-clay was discontinued. It is now raised and thrown on the dump or stored in the worked-out areas. It costs 30 cents a ton to handle it, and when shipped brought 50 to 65 cents on the cars at the mine. Two carloads of it were shipped to the Uhl Pottery Company, at Evansville, in 1903 and burned into fire brick and stoneware. The fire brick, when tested, stood up well under a temperature as high as 2,900° F., but beyond that point began to fuse. It will serve well for terra cotta, hollow building block, conduits and similar wares.

Southeast of this mine, in the west half of section 4, The Rockport Clay and Mining Co., E. L. Boyd, Manager, own 185 acres which is underlain with the same grade of clay, from eight to 11 feet in thickness. The overlying coal III is here three and a quarter to four feet thick. The Cannelton branch of the

Southern Railway passes through the tract, so that transportation, fuel and raw material are all together.

Lincoln City is a growing town and an important junction point on the Southern Railway. With large deposits of shale, under-clay and coal in its immediate vicinity and with good railway facilities it offers excellent advantages for the location of a great clay industry.

Aside from the above mentioned points close to Lincoln City, coal IIIa, with its underlying clay and shale, 15 or more feet thick, outcrops 300 yards south of the center of the east half of 11, one-half mile northeast of the Cannelton branch; also near the center of the north half of section 2.

In that portion of 5 S., 6 W., in Spencer County, coal III is worked in several places. On the southwest quarter of section 2 it overlies five feet of a good grade of under-clay.

Townships 6 and 7 South, Ranges 4 and 5, and Parts of 3 and 6 West.

This area of about 180 square miles comprises the south half of the county, and as it contains few clay deposits will be treated but briefly. At Gages' Hill, northeast quarter of 16 (6 S., 4 W.), a coal two and a half feet thick at 38 feet from the surface overlies four feet of under-clay; while near the foot of the hill, 22 feet of blue clayey shale is exposed above another two and a half foot vein of coal, with five or more feet of under-clay beneath.

Near Newtonville, in the southeastern corner of section 10 (6 S., 5 W.), coal IIIa, six inches thick outcrops on several of the ridges and overlies three feet of under-clay and 10 to 15 feet of drab clay shale, both of good working quality.

Along the east-west road, in the southwest quarter of section 1 (6 S., 6 W.), just northeast of Chrisney, there is a fine exposure of drab to blue clayey shale, 12 to 14 feet in thickness. The same bed outcrops at a number of other places over the township and could be burned into a variety of clay products.

At the Irvin drift slope, in the northwest of the southwest of 4 (6 S., 6 W.), coal III, 22 inches thick, overlies five or more feet of a soft blue gray under-clay. The under-clay below coal

IV, at the Fisher and other mines in sections 16, 17 and 28, contains too much sulphur to burn into clay wares.

Three miles northwest of Rockport, on the land of Geo. Shrode, east half of section 4 (7 S., 6 W.), is a thin seam of coal IIIa, beneath which is a vein of much better under-clay, more than four feet in thickness. It is fine grained, light colored and siliceous, and appears in every way suitable for potters' use, or for the making of hollow vitrified wares.

The Eigenmann Contract Company for a number of years had a large brick yard a short distance north of Rockport, on which the following section was exposed:

Section on Brickyard of Eigenmann Contract Co.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil (stripped)	1	0
2. Yellow loess clay	7	0
3. Sand (bottom concealed)	20	0

The yellow clay is the characteristic loess clay of southwestern Indiana. It makes an excellent stock brick and, as has been proven at Huntingburg, can also be made into a good grade of red pressed front brick. The sand (No. 3) of the above section is a good molding material, and large quantities of it are annually shipped for that purpose to various towns on the Southern Railway.

At Mariah Hill building brick are made on a small scale from the loess clay, the latter being used to a depth of six to eight feet. At St. Meinrad, 12 feet of similar material are used without stripping for brick and drain tile. Near Rockport, F. M. Underhill uses an alluvial surface clay 10 feet thick, after stripping six inches of soil in making brick and drain tile, the value of the output in 1904 being \$7,618. At Lake, the Palmer Drain Tile Company make common brick, hollow block, drain and roofing tile from a surface clay three feet in thickness, after removing six inches of soil.*

* For further information regarding these factories see table near end of paper.

PERRY COUNTY.

This county lies on the southern border of Indiana, just west of and adjoining the western meridian of the State. It lies south of Dubois and Crawford; west of Crawford and east of Spencer counties. On the south, east and west it is also partly bordered by Kentucky, from which it is separated by the Ohio River. It has an extreme length from north to south of about 28 miles, and width from east to west of about 25 miles, with an area of 383 square miles.

The rocks of three geological epochs form the surface of the county, viz., the Coal Measures and Mansfield Sandstone of the Carboniferous and the Huron limestones and sandstones of the Lower Carboniferous periods. The rocks of the Huron group form the surface of the greater part of the eastern half and are exposed in the valleys of the streams of the western half of the county. The surface of the western half is about equally divided between the Coal Measures and Mansfield Sandstone proper, the former forming the crests of the higher ridges and hills, while the latter outcrops along the slopes and forms the surface of the lower hills. As a rule the surface of this county is very broken, the hills rising from 250 to 400 feet above the main valleys, and often showing bluffs of sandstone or limestone. Some flat country occurs along the Ohio and the larger streams in the form of bottoms.

Anderson Creek forms the greater part of its western boundary and drains the western half of the county, its main tributaries being Hurricane Fork from the north, Middle Fork from the southeast and Brushy Fork from the east, each with numerous branches. In the southern part of the county are Windy, Deer and Little creeks; then, flowing somewhat easterly, Poison, Little Poison and Oil creeks, all of which flow into the Ohio. Little Blue River just touches the northeastern corner.

The only railway in the county is the Cannelton Branch of the St. Louis Division of the Southern which, entering the southwest corner, passes through Tell City and has one of its terminals at Cannelton, the county seat. The Ohio River, with a frontage of nearly 50 miles, offers cheap and excellent transportation facilities for the southern portion, but the greater part of the northern two-thirds is distant eight to 20 miles from railway or river.

Coals IIa, II and I occur in the county, coal II being the only workable vein, and that only in basins of small area. The underclays beneath coals IIa and II are of excellent quality for stoneware and hollow vitrified products, and have been extensively used for such wares.

Townships 6 and 7 South, Ranges 2 and 3 West.

This area of about 90 square miles comprises the greater parts of the civil townships of Troy and Tobin in the southwestern portion of the county, and embraces the territory in which the most available and valuable of the commercial clays occur, and the only part of the county which will be treated in this report. The greater portion of township 7 south, 2 west, lies in what is known as the "pocket," a big bend which the Ohio makes to the south. The surface of the area is quite rugged and hilly, the hills rising from 250 to 320 feet above high water. Bold cliffs of sandstone face the river in many places. In some of the valleys adjoining the Ohio the cliffs have broken up into "rock houses," adding much to their picturesqueness. Besides the cheap and convenient means of transportation afforded by the river, the Cannelton Branch of the Southern Railway gives railway connection with the main line. The Louisville, Henderson & St. Louis Railway skirts the river bank on the Kentucky side of the river, affording direct communication by rail with Louisville.

Perry County has long been known for its clay industries. The first pottery of importance in the State of Indiana was located, in 1834, on the banks of the Ohio, a short distance above the town of Troy. James Clews, a wealthy individual of Liverpool, England, had previously visited the place and made careful investigation of the clays underlying the veins of coals IIa and II. From the crude tests which he made he believed them to be fitted for making a light colored grade of porcelain ware. Returning to England he organized a colony of more than 600 persons, many of whom were skilled potters. These he brought to Troy, and burning ordinary brick for factories and dwellings, and fire brick for kilns, soon had a large industry in operation. To this he gave the name of the "Indiana Pottery Company." Some of the buildings erected were two stories in height and more than 200 feet long.

Unfortunately the clays of Troy proved unfit for the making of white ware; and the company had to ship in lighter clays and mix with them, and content itself with manufacturing a yellow or Troy ware which, in time, came to be much used in southern Indiana. This was, however, unsatisfactory to the leading members, and about 1840 the pottery was abandoned and allowed to go to ruin.

In 1863 a pottery was started on a small scale in one of the old buildings by B. Hincho. Some years later he abandoned this site and erected a new pottery in the town of Troy, where he manufactured from the under-clay of the top vein of coal, a mahogany colored Rockingham ware until 1892, when old age caused him to desist. As a practical potter of long experience, Mr. Hincho claimed that the clay found beneath coal IIa in the vicinity of Troy, and used by the Indiana Pottery Company and himself, can not be excelled for the making of terra cotta, ordinary stoneware, or the darker and more expensive Rockingham ware; but by itself burns too dark for the "yellow ware" such as the old company made. In 1865, Samuel Wilson started a pottery in the town of Troy, which he operated until his death in 1891. He made both yellow and Rockingham ware, the former from clay shipped in from Ohio which closely resembled the potters' clay found in the vicinity of Clay City, Indiana.

Near the site of the factories of the old Indiana Pottery Company, one-half mile southeast of Troy, the shaft of the Bergenroth Bros. Coal mine is located. One hundred yards east is the clay pit of the old company. The following connected section was obtained at this point, beginning on the slope of the hillside, southwest quarter of section 18 (6 S., 4 W.), a few yards east of the section line which runs through the old pit:

Section near old Clay Pit, east of Troy.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil and yellow surface clay	17	0
2. Shaly sandstone	10	0
3. Black sheety clay shale	5	0
4. Coal IIa	0	6
5. Potters' clay	6	4
6. Sandstone, massive	33	0
7. Coal II	3	2
8. Under-clay	3+	0

According to Mr. Hinch, the vein of 'potters' clay, No. 5, becomes thicker farther back under the hill, and at the point worked by him, a few hundred yards east of Troy, was fully 12 feet in thickness. It is an exceedingly close grained, light colored clay and stands up well under heat sufficient to melt the mixture of lead oxide, manganese and sand used in glazing the Rockingham ware. It is practically the same clay as is used at Cannelton, an analysis of which is given on a subsequent page.

Coal II is the vein mined by the Bergenroth Bros., and is the same seam as is worked at Cannelton. It is not a cannel coal but a semi-caking bituminous, and ranks high as a fuel. It is mostly sold to steamboatmen on the river, and is used by the engines on the Cannelton Branch of the Southern Railway. This road runs within 20 feet of the shaft, and directly past the outcrops of clay mentioned above, passing over some of the foundations of the old pottery, which are buried beneath the soil washed down from the adjacent hillsides.

At the Reed mine, in the northeast quarter of section 26 (6 S., 3 W.), the under-clay beneath coal II is six feet thick. The same bed of under-clay, averaging five to six feet in thickness, outcrops with the coal, on the southeast of 25; on the southwest of 24; on the northeast, southeast and southwest of 27; in the northwest of 29; the southeast of 19, and the south half of 20; all in 6 S., 3 W., north and northeast of Troy.

In 1862 Clark Bros. established at Cannelton, the present county seat of Perry County, a factory for the manufacture of sewer pipe. This, for more than 30 years, was the only establishment of its kind in the State. Ten years later Wm. Clark erected by the side of the sewer pipe factory a large stoneware pottery. Both of these were operated until 1902, when the stoneware factory burned. It was for many years the largest concern of its kind in Indiana. The clay used in both factories was the under-clay found so extensively in the vicinity of Cannelton beneath the top coal. That at present used in the sewer pipe works is hauled in wagons from a point three-quarters of a mile north of the center of the town, northeast of the southeast of 9 (7 S., 3 W.), where the vein of clay beneath coal IIa is nine feet in thickness. (See Pl. XVI.) Just below the under-clay in the pit is a tough blue clayey shale, eight or more feet thick. These

two are excavated and mixed in about equal proportions for use in making sewer pipe. The contractor pays five cents per ton royalty for the clay, and receives 85 cents per load of 3,500 pounds delivered at the sewer pipe factory. Since the death of the former owner, A. D. Clark, the factory is run only on a small scale. But five loads of the clay are used each day.

The clay formerly used at the Clark Bros. Sewer Pipe and Stoneware factories was obtained from beneath coal IIa, on the land of the American Cannel Coal Company, about a mile north-east of Cannelton. Where it was obtained the coal was absent in many places and the clay was secured by stripping the surface to a depth of one to six feet. The upper half of the vein, a light gray plastic clay of very fine texture, was used mostly for stoneware. Care had to be taken in selecting it, however, as in some places it contained particles of pyrites which, after burning, caused a flaking of small pieces from the surface of the ware, and so rendered it unsalable. The lower half of the vein was coarse grained and had more of a reddish yellow tinge, due to a larger percentage of iron oxide. It was found to be better suited to the making of sewer pipe, as it vitrified at a lower temperature than the upper, and burned to a darker color. No trouble with the "poppers," or particles of iron pyrites was experienced in the making of sewer pipe. This clay resembles shale somewhat in possessing a laminated appearance, but that it is a true under-clay of good refractory grade is shown by the following partial analysis made by Dr. Hurty of a sample of the upper part of the stratum.

*Partial Analysis of Clay formerly used in making Stoneware and Sewer Pipe,
at Cannelton.*

Silica (SiO_2)	65.830
Alumina (Al_2O_3)	22.940
Clay base and sand	88.770
Magnesia (MgO}) .....	.858
Lime (CaO}) .....	.308
Ferric oxide (Fe_2O_3)	2.640
Fluxes	3.806
Moisture and volatile	7.494*

*This probably includes one or two per cent. of potash and soda. Compare the second column of this analysis with the standard average of Ohio stoneware clays given on another page.

One-half mile northeast of Cannelton is the old pottery of the Cannelton Stoneware Co., now operated by Clark, Rose & Co.,* with an output of about 200,000 gallons of stoneware per year. The clay used is the light gray potters' clay from beneath coal IIa, and is secured from the land of the American Cannel Coal Co., about two miles north of the pottery. It costs \$1.00 per ton delivered, which includes five cents royalty and 37½ cents for hauling. Coal costing six cents per bushel is used for fuel. It is secured from the American Cannel Coal Co., and hauled on a dummy railway which passes by the pottery.

Mr. O. C. Lee, the former superintendent of the Cannelton Stoneware Co., at one time made a number of private tests which go to prove the value of a better system of preparing the potters' clay found beneath coal IIa in the vicinity of Troy and Cannelton. He showed me samples of vases and jars made from the washed clay which were superior in design and finish. They were unglazed, and when burned were of the peculiar stone-gray color of the raw material. They prove this clay, when properly prepared, to be well suited for the finest of decorative work. If washed before being burned into stoneware, a much better quality of the latter could be made, and the increased price which it would readily bring would more than repay the extra expense of preparation.

The American Cannel Coal Co. owns several thousand acres of land adjoining Cannelton on the north and east, and for years has carried on the mining of coal and the quarrying of sandstone on an extensive scale. The main vein of coal II has been worked at a number of places, mostly by slope or drift shafts. The following connected section obtained one and a fourth miles east of Cannelton, on the southeast quarter of the northeast quarter of section 10 (7 S., 3 W.), may be taken as representing the average sequence of the strata through the worked seam of coal over a large area of the company's land:

Section east of Cannelton, on Land of American Cannel Coal Co.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil and yellow clay.....	6	0
2. Gray sandy shale.....	14	0
3. Sandstone	8	0

* See also under "Clayworking Industries of Indiana."

4. Blue sandy shale.....	11	0
5. Coal IIa	1	3
6. Potters' clay	6	0
7. Blue clayey shale.....	34	0
8. Black bituminous shale.....	1	6
9. Coal II	4	0
10. Under-clay	5	0
11. Sandstone	20	0

Large quantities of shale No. 7 and under-clay No. 10 have to be handled each year to make height in the rooms and entries of the mines. Neither of these have heretofore been put to use, though excellent samples of dry pressed front brick have been made from them for the company. Shale No. 7 is a close grained material, very free from impurities. Its composition, as shown by an analysis made for this report by Dr. Noyes, shows the presence of the following constituents:

Analysis of Clay Shale No. 7, from above Coal II, on the Land of the American Cannel Coal Co., near Cannelton.

Silica (SiO_2)	53.26
Titanium (TiO_2)	1.05
Alumina (Al_2O_3)	25.77
Water combined	7.00
<hr/>	
Clay base and sand.....	87.08
Ferric oxide (Fe_2O_3)	3.32
Ferrous oxide (FeO).....	3.82
Lime (CaO}) .....	.32
Magnesia (MgO)	1.90
Potash (K_2O)	2.54
Soda (Na_2O}) .....	.44
<hr/>	
Fluxes	12.34
Carbon dioxide (CO_2).....	1.10
<hr/>	
Total	100.52

This analysis proves its chemical fitness for making vitrified products of many kinds; as the percentages given are very close to those of the average shales used for such products. A practical test of its utility for sewer pipe making is given above, where it is shown that shale from the same stratum is being mixed with the overlying potters' clay and used at the Clark Sewer Pipe Factory in Cannelton.

The under-clay (No. 10) burns to a handsome buff color and will make good terra cotta, hollow building block, conduits, flue linings, etc., or it can be mixed with the overlying shale to make paving brick or sewer pipe. It contains too great a percentage of fluxing impurities to make refractory wares, as the following composition from analysis made by Dr. Noyes will show:

Analysis of Under-clay from beneath Coal II, from the Mine of the American Cannel Coal Co., near Cannelton.

Silica (SiO_2)	57.57
Titanium oxide (TiO_2)	1.10
Alumina (Al_2O_3)	21.70
Water combined	6.78
<hr/>	
Clay base and sand	87.15
Ferric oxide (Fe_2O_3)	2.26
Ferrous oxide (FeO)	4.11
Lime (CaO}) .....	.32
Magnesia (MgO)	1.12
Potash (K_2O)	2.16
Soda (Na_2O}) .....	.33
<hr/>	
Fluxes	10.30
Carbon dioxide (CO_2)	1.73
<hr/>	
Total	99.18

In the winter and spring of 1903 the American Cannel Coal Co. shipped 30 or more carloads of the potters' clay from beneath coal IIa to the John Bauer pottery at Louisville and the Uhl Pottery at Evansville. They paid 35 cents per ton for mining the clay, 15 cents for hauling it to the cars, and received 75 cents, f. o. b. at Cannelton. The clay was secured from near the top of the hill north of Cannelton, southeast quarter of section 9 (7 S., 3 W.), about one-eighth of a mile east of the pit, now worked for the Clark Sewer Pipe Co. It was mined from a slope shaft entering the hill beneath a heavy ledge of sandstone, the clay being about five feet thick, beneath a 10 inch vein of coal. The Bauer Company was well satisfied with the clay, but Superintendent Lee, of the Uhl Pottery, states that it will not stand up under the temperature necessary to take a white glaze, and as all his stoneware is glazed with a white bristol glaze its use was discontinued. For sewer pipe making, Mr. Lee

states that the lower under-clay at Cannelton—that found beneath coal II—“can not be surpassed in the United States.”

The American Cannel Coal Co. had a number of practical tests made of their clay and shales in the spring of 1904, by the American Clay Working Machinery Co., of Bucyrus, Ohio. The clays sent were from the slope mine in the north edge of Cannelton, and from the old Clark clay pit, a mile and a half northeast. The samples returned were in part as follows: (a) Hollow building block made from the shale No. 7, which were a handsome chestnut brown in color, strong and durable, with a clear metallic ring; (b) a large piece of special shaped coping, made from under-clay No. 10, which shows its fitness for such material and for terra cotta; (c) vitrified drain tile, grayish brown in hue and of high grade; (d) buff pressed front brick from under-clay No. 10.

The Boyd Press Front Brick Co., of Chicago, also made a number of buff, brown and mottled dry pressed front brick from the under-clays, which were very fine in appearance and of seemingly good quality.

The yellow loess surface clay which crowns the hills about Cannelton to a depth of six to eight feet, is a superior article of its kind. The Cannelton Stoneware Co. at one time made from it ordinary soft mud brick, which were but little inferior in appearance to some of the pressed front brick used in our cities. Mr. George Hufnagle, of Cannelton, has had sample dry pressed brick made from it which were very handsome in appearance. From deposits of shale and under-clay on his farm, section 9 (7 S., 3 W.), he has had other samples burned, the shales making a dark maroon brick which can not be excelled in quality, and the under-clay a fair grade of buff front brick.

All in all, the clays found at available points in southern Perry County are excellent in quality, and in quantity practically inexhaustible. From them ordinary building brick, sewer pipe, stoneware, vitrified drain tile and Rockingham ware, *all of good quality, have been made in the past*, while paving, pressed front and hollow brick and terra cotta can undoubtedly be made. Fuel of excellent quality, awaiting only the pick of the miner, underlies these clays. The Ohio River furnishes an ever ready means of transportation, where not one company, but many, com-

pete for freight, and so keep the rates at a very low figure; while the Southern Railway has a branch line passing within one-half mile of all the chief clay deposits. With these facilities present no better site for the location of large clay factories exist in southern Indiana. The one thing lacking is a railway running northeast from either Cannelton or Tell City via Bloomington, Monroe County, to Indianapolis. Such a road would pass through the main Oölitic limestone district of the State, and would open up a vast territory rich in many kinds of undeveloped resources.

II. COUNTIES OF THE LOWER CARBONIFEROUS AREA.*

As already noted, the Lower Carboniferous or Mississippian Period is represented in Indiana by the rocks of six Geological Epochs, viz., the Goniatic Limestone; the Knobstone shales and sandstones; the Harrodsburgh, Bedford and Mitchell limestones, and the Huron limestones and sandstones. Of these, the Goniatic Limestone covers so small an area that it will not be treated in this connection. The clays of the area covered by the rocks of the other epochs of the Lower Carboniferous Period will be treated under two heads, viz., (a) Clays of the counties comprising the Knobstone area. (b) Clays of the counties comprising the Lower Carboniferous Limestone area. Since the Knobstone shales will in time rank next to the shales and under-clays of the Coal Measures in clay working value, they will be first considered.

(a) Clays of the Counties Comprising the Knobstone Area.

The general features of the Knobstone area of Indiana have already been discussed in Section II of this paper, and more fully in a paper by Prof. J. F. Newsom in the Twenty-sixth Report of this Department. Of the counties in which the Knobstone shales outcrop, listed on page 48 of this paper, Owen, Fountain and Warren have been considered in the preceding subsection, since the greater portion of their respective areas is covered by rocks of the Carboniferous Period. Of the remaining counties, Harrison, Clark, Scott, Lawrence, Monroe, Bartholomew, Johnson, Putnam, Marion, Boone, Clinton, Tippecanoe, White, Benton and Jasper have the greater part of their respective areas covered by the rocks of other epochs. The remaining counties, viz., Montgomery, Hendricks, Morgan, Brown, Jackson, Washington and Floyd are the ones which will be considered under the present heading, in the order mentioned from north to south.

MONTGOMERY COUNTY.

This county lies in the west-central part of the State, about 45 miles northwest of Indianapolis. It is bounded on the north by Tippecanoe, on the east by Clinton, Boone and Hendricks,

* For the list of counties comprising this area see p. 147.

on the south by Putnam and Parke, and on the west by Parke and Fountain counties. In shape it is quadrangular, 24 miles in length from north to south, and 21 miles in width; its area being 504 square miles.

Almost the entire area of the county is covered with a heavy mantle of drift. Beneath this the Knobstone rocks form the surface, except over small isolated areas along Sugar Creek, where they are overlain by the formation known as the Harrodsburg limestone. The latter also comes to the surface along the southern border of the western half, while the Mansfield sandstone occurs over about eight square miles along the western border of the southwestern fourth. A small isolated area of Mitchell limestone also outcrops in the extreme southwestern corner.

The northern part of the county was originally a region of extensive prairies, surrounded by glades and groves of timber. The western and especially the southwestern portion, near the principal streams, is hilly and broken, while the eastern and southeastern portions are generally flat and level. The latter regions were, when first settled by the Whites, covered with a heavy growth of fine timber. Near the center of the southern half is an irregular area of some 60 square miles, New Market being near its center, which was formerly the site of a lake. To this area Dr. John Collett gave the name "Ancient Lake Harney." Its surface is low and flat, and has required much tiling to fit it for cultivation.

The main drainage stream of the county is Sugar Creek, which flows diagonally across its area from northeast to southwest. It has a number of tributaries which, with their branches, are fed by springs which flow out of the great masses of clay, gravel and other drift material which form a thick bed above the underlying sedimentary rock. The principal ones of these from the north are Lye and Black creeks, while from the south and east, enter Walnut, Offield and Indian creeks. The southeastern portion is drained by Big Raccoon and the southwestern by Little Raccoon creeks; while the waters of the northwestern corner find an outlet through Coal Creek into the Wabash.

The railway facilities of the county are excellent. The O., I. & L. (Monon) passes through it from north to south near the

center; the T. H. & L. Division of the Vandalia from southwest to northeast, and the Peoria Division of the Big Four from east to west, all converging at Crawfordsville, the county seat. In addition to this, the T., St. L. & K. C. (Clover Leaf) crosses a portion of the northern border, and the Central Indiana the southern border, both running in a northeast-southwest direction.

The Knobstone rocks, consisting of thinly laminated shales and shaly sandstones, are exposed in the bluffs of Sugar Creek where it enters the county, and at numerous places along that stream and its tributaries to Yountsville and below; also on Big Raccoon Creek near Ladoga in the southeastern corner. In general these exposures are too highly siliceous for clay working purposes, but north and northeast of Crawfordsville, they partake more of the character of clay shales, and here they are being utilized on an extensive scale.

The largest factory putting them to use is that of the Poston Paving Brick Company which, in 1901, erected a modern and well equipped plant for the making of stiff mud repressed vitrified brick at Crawfordsville Junction.* Mr. I. G. Poston, the promoter and general manager of the plant, was for eight years in charge of the Wabash Clay Co.'s vitrified brick plant at Veedersburg. He is one of the most practical and experienced paving brick manufacturers in the country, and the originator and patentee of the famous "Poston Paving Block." For some time he experimented with these Knobstone shales and fully convinced himself of the practicability of their utilization for paving brick purposes. The high tests which his Knob shale block have since undergone have fully proven the fitness of the material for such products, and his factory is but the pioneer of a number of others which, in the near future, will be erected at various places in the Knobstone area of the State.

The shale used at the Poston Brick Co.'s plant at Crawfordsville Junction is obtained on the north side of Walnut Creek, a mile and a quarter north of the plant, southwest quarter of section 28 (19 N., 4 W.), where the company owns 21 acres. A switch of the T. H. & L. Railway has been built from the main line to the south bank of the creek opposite the shale bank, and

*For a full description of this plant and its output, see under subsequent section entitled "The Clay Industries of Indiana."

the shale is hauled in flat cars to the plant at a cost of \$2.00 per car. A contractor receives 18 cents per ton for excavating the shale and loading it into the railway cars on the south side of the creek. About 150 tons are used each day. He first loads it into small tram cars which are propelled by steam power across a bridge and automatically dumped.

The shale stratum outcrops 20 to 50 feet in thickness between the worked pit and the mouth of Walnut Creek, three-quarters of a mile to the northwest. Many springs occur along the base of the exposure. In May, 1904, a section at the pit showed as follows:

Section of Clay Pit of Poston Paving Brick Co.

	<i>Fet.</i>	<i>Inches.</i>
1. Soil and clay stripped.....	3	6
2. Buff to drab partly decomposed shale.....	4	0
3. Gray shale in thin layers.....	26	0
4. Blue gray shale in thick layers.....	10	0
5. Blue shale exposed to bottom of stream.....	12	0

Nos. 2 to 4, inclusive, were being used. The laminae or layers of No. 3 were one to three inches in thickness, while No. 4 was made up of four or five layers, two or three of which were 15 to 30 inches in thickness. The top of one of these thick layers formed the bottom or floor of the pit, which was very smooth, level and free from debris. When exposed for some time the thick layers split up into thinner ones similar to those found nearer the surface. The buff color of the upper portion is due to the leaching of the overlying surface deposits. No ironstone nodules such as occur abundantly in the Knobstone farther south were visible.

The shale, when ground, is not as plastic as the majority of the Carboniferous shales to the west and south. It requires 10 horse power more to grind and work than the Veedersburg shale. Its tenacity is not as great, and some care is necessary in handling the unburned wares. The combined water is readily driven off in the kiln, and the finished brick are not glassy but somewhat granular and very hard and tough. In more plastic shales the outer portion of the brick sometimes vitrifies and retains the combined water of the central portions which, being changed into steam, causes the brick to bulge in the center. No such bulging



Knobstone Shale Pit of Poston Paving Brick Co., one and a half miles northeast of Crawfordsville, Montgomery County. Showing effect of shot with 150 pounds of dynamite.



View of same Pit across Walnut Creek.

occurs with the Knobstone shale when properly burned. But little shrinkage takes place and an average of 68 to 72 per cent. of "firsts" are secured from each kiln. They are 3½x4x9 inches in size and weigh 10 pounds. The plant is run ten hours a day for 11 months of the year. Thirty-thousand block are made each day, the value of the output in 1904 being \$80,000.

On the west side of the Monon Railway, about three-quarters of a mile northwest of the shale pit above mentioned, and a mile and a half north of Crawfordsville, the Everson & Ferguson Brick Co. began, in 1901, to make soft mud, sand molded brick from the Knobstone shale. The company make 22,000 brick per day for six to eight months of the year, the output in 1904 being 1,800,000. These bring \$5.50 to \$6.00 per thousand, f. o. b. cars at the plant, or \$7.00 delivered in the city.

The ledge of shale used is about 100 yards north of the plant, on the south side of a ravine leading down into Sugar Creek. The stripping of soil and surface clay averages about three feet and the side of the exposure measures 24 feet, all buff to drab in color. The upper 15 feet of buff shale is in thin layers, much broken by weathering. About 48 tram cars, or 55 tons, are used each day, being hauled up an incline by steam power to the side of the crusher and dry pan. A well by the side of the plant passed through three feet of soil and surface clay and 60 feet of Knob shale without reaching the bottom of the latter. The brick shrink but little, are of good quality, being bright cherry red in color, weigh 4½ pounds each and are homogeneous in texture. They have a ready sale at railway points within 30 miles of Crawfordsville, as well as in that city. They cost \$4.10 to \$4.25 on board the cars at the plant. Island City coal, costing \$2.35 per ton at the plant, is used as fuel, and Connellsville coke for water-smoking.

On the east side of the Monon Railway, opposite and a little below the above-mentioned plant, is the factory of the Standard Brick Co.,* erected in 1893 for the making of dry pressed front brick from the Knobstone shale. On account of dissensions among the former owners, the plant has not been operated steadily for two or three years. When running, the shale was secured from the low bank exposed by the railway cut and on its western

*See description of plant under "Clay Industries of Indiana."

side, and was hauled in dump carts across the railway. From three to five feet of soil and gravel have to be removed to reach the shale.

The Knobstone shale outcrops along Walnut Creek for two or three miles above the pit of the Poston Paving Brick Co., and in many places along Sugar Creek to the eastern edge of the county. Just above the mouth of Walnut Creek, in the southeast quarter of 20 (19 N., 4 W.), is a thick deposit of dark shaly clay of good quality for manufacturing. A little prospecting would disclose a number of places near the railways north and northeast of Crawfordsville, where the clay substance of the shales is high enough to justify their use for paving, pressed-front or ordinary brick-making.

At the Cascade Bridge, near Yountsville, in the southeast quarter of section 3 (18 N., 5 W.), the blue "soapstone shale" outcrops 28 feet thick below 42 feet of overlying sandstone and limestone. At Hemlock Bluff, a half mile below the town, the outcrop of blue and gray Knobstone shale is 75 feet thick, with about 50 feet of cover.

A short distance east of Ladoga is the first rock outcrop along Raccoon Creek, between that place and the old milldam near New Ross. At the Monon Railway bridge at Ladoga, southeast quarter section 18 (17 N., 3 W.), the following section is exposed:

Section at Monon Bridge at Ladoga.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil and drift	8	0
2. Gray shaly knob sandstone	18	0
3. Blue clayey sandstone.....	4	0

Just below the wagon bridge the shaly Knob sandstone runs 12 to 20 feet in thickness, with a thin layer of pebbly conglomerate exposed near the bottom. Similar outcrops of the shaly sandstone occur on the old Graybill farm, in the northeast quarter of section 27 (17 N., 4 W.), about five miles southwest of the town. At all these places the Knobstone is too high in silica to work into clay products, unless mixed with a more plastic material.

Below the "Shades of Death," in the northwest of the northeast of section 10, the sub-conglomerate coal I outcrops in several

quarter-inch to half-inch seams just below the lowest ledge of Mansfield sandstone. Below the coal is eight to 10 feet of underclay and clay shale, which could be burned into vitrified wares. The location is, however, four miles distant from a railway. The same vein of coal, with clay and shale beneath, outcrops at various points in the southwestern corner of the county, as follows: Southeast of southeast of section 25, southwest of southwest of 25, northwest of northwest of 36, and southeast of southwest of 35 (18 N., 6 W.); southwest of northeast of section 23 and northwest of southeast of 23 (17 N., 6 W.)

From the drift clays of the country ordinary brick and drain tile are being made in a number of localities. In general the soil and sod, where present, to a depth of 8 to 12 inches, is stripped and three to five feet of the underlying clay then used. The largest factories are located at New Richmond, New Market, New Ross and Crawfordsville, the value of the annual output of each ranging from \$2,700 to \$10,000.*

HENDRICKS COUNTY.

Hendricks County lies just west of the center of the State. It is bounded on the north by Boone, on the east by Marion and Morgan, on the south by Morgan and on the west by Putnam and Montgomery. In outline it is nearly square, being $19\frac{1}{2}$ miles in greatest width from east to west by 22 miles in greatest length, and comprises an area of 408 square miles. Except along the streams, the entire area of the county is covered by a heavy mantle of drift, beneath which the Knobstone shale of the Lower Carboniferous and the Genesee shale of the Devonian periods form the surface rocks. From wells and bores, the latter formation is believed to be confined to the northeastern fourth of the county, but its exact limits are unknown. The only outcrops are those of the Knobstone, in the central and southwestern portions.

The general surface of Hendricks County is considerably higher than that of the adjacent counties, and is, therefore, well provided with natural drainage and has a porous and easily cultivated soil. As a general thing the surface is rolling, though considerable portions of it are quite level. It produces excellent crops

*See statistical table at end of paper for more detailed report of these factories.

of wheat, corn and blue grass, and ranks high as an agricultural county. Along the creeks and streams there is some broken land, but only a very small percentage is unfit for successful cultivation.

The northwestern fourth of the county is drained by Eel River or Big Walnut Creek and its various branches. This stream is the principal tributary of the West Fork of White River, and has its source in these smaller streams of northwestern Hendricks and southern Boone counties. White Lick Creek and its tributaries drain the eastern half of the county, while Mud and Mill creeks drain the southwestern portion. The large number of water courses which meander through the county in nearly all directions, together with the peculiar adaptation of the soil to blue grass and other grasses, which here grow spontaneously, give Hendricks County superior advantages for the raising of live stock, especially cattle.

The railway facilities of the county are good. The Peoria Division of the Big Four runs diagonally across the northeastern fourth, while the St. Louis Division crosses from east to west near the center. The Springfield Division of the C., H. & D. and the Vandalia cross, respectively, the northern and southern thirds from east to west. No portion of the county is, therefore, distant more than six miles from a railway. In addition to these, the Indianapolis & Plainfield electric line has one of its terminals at the latter town, while the Indianapolis & Danville line will soon be completed to Danville.

The only clay-working materials of the county are the Knobstone shales, where they occur close enough to the surface, and the yellow drift clays, where they are free enough from lime pebbles. The best and most available shale deposits are just south and southeast of Danville, the county seat. Since they are near the eastern margin of the Knobstone area, they are higher in clay substance and lower in silica than those found farther west.

Along a branch of White Lick Creek, on the land of R. T. Hollowell, one mile south of the Big Four Railway station at Danville, east half of section 16 (15 N., 1 W.), the Knob shale outcrops for nearly one-fourth mile. The exposures are 10 to 15 feet thick, with bottom hidden, and with yellow drift clay, 3 to

10 feet thick, overlying. The shale, where weathered at the base of the exposure, forms a fine-grained, dove-colored clay, quite tough and very plastic. It is seemingly well fitted for the clay ingredient of Portland cement, and can be burned into paving brick, sewer pipe or hollow vitrified products. It will make a high grade ordinary brick or a good pressed front brick. If used for the last two products, much of the overlying surface could be mixed with it.

Two fine springs issue from just above the shale on the Hollowell property, and furnish an abundance of running water. Connected with one of them is a hydraulic ram, which forces the water to the house and barn on the premises. An analysis of the water from each of the springs has been made by Dr. J. N. Hurty, and the composition found to be as follows:

Analyses of Spring Water from the Land of R. T. Hollowell, south of Danville.

	<i>Grains per U. S. Gallon.</i>	
	<i>East Spring.</i>	<i>West Spring.</i>
Silica (SiO_2) .....	.68	.30
Iron oxide and alumina ($\text{Fe}_2\text{O}_3 + \text{Al}_2\text{O}_3$) .....	.18	.18
Calcium carbonate (CaCO_3)	16.41	16.89
Calcium sulphate (CaSO_4) .....	....	.80
Magnesium carbonate (MgCO_3)	5.26	3.88
Magnesium sulphate (MgSO_4)	2.16	.25
Total	34.69	22.30

"These waters are not medicinal, as they contain only ordinary ingredients in ordinary proportions. They are, however, very pure; that is, they are free from organic matter and germs. They belong to the same class as Waukesha, Buffalo Lithia, Tuckaho Lithia, etc. They are valuable simply as very pure, soft drinking waters."

J. N. HURTY.

On the Joseph H. Johnston farm, just south of Hollowells, is another branch of White Lick Creek, along which the Knob shale outcrops in bold bluffs, 20 to 30 feet thick, with little cover above. It also occurs close to the surface along the same branch, on the land of H. A. Record, south half of the southwest quarter of section 15 (15 N., 1 W.).

Still farther southeast, on the Arthur Hadley farm, north half of the northeast quarter of 22, bluffs of the shale, 25 to 40 feet thick, occur on the south side of a branch of White Lick and less

than one-fourth mile from the main stream. The shale in these bluffs is overlain with about three feet of surface soil and clay, and could be easily and cheaply secured. A well at the Hadley residence, a quarter of a mile northeast, struck the top of the shale stratum 10 feet from the surface and went 186 feet into it without finding its bottom or striking water. The main exposures of the shale are two miles north of the Vandalia Railway, but a spur to them could be easily constructed up the valley of White Lick. They are a quarter of a mile west of the Lieber survey of the Danville & Plainfield electric railway and one and three-quarter miles from the Big Four at Danville.

Samples from near the foot of one of the bluffs were analyzed by Dr. Noyes and the composition found to be as follows:

Analysis of Knobstone Shale from Land of Arthur Hadley.

Silica (SiO_2)	70.84
Titanium oxide (TiO_2).....	.18
Alumina (Al_2O_3)	14.73
Water combined (H_2O).....	3.32
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Clay base and sand.....	89.07
Ferrous oxide (FeO).....	4.82
Lime (CaO)38
Magnesia (MgO)	1.36
Potash (K_2O)	3.15
Soda (Na_2O)	1.42
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Fluxes	11.13
Carbon dioxide (CO_2).....	.21
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Total	100.41

The analysis proves the chemical fitness of the shale for paving brick and other vitrified products. It is rather high in silica to serve as the clay ingredient of Portland cement. A quantity of the shale was sent to Chicago and burned into sample dry pressed front brick by the Chisholm, Boyd & White Co. A sample brick, dark cherry red in color, was shown me, which appeared to be a high-grade brick in every particular, and fully bore out the following extract from a letter from the C., B. & W. Co. to Mr. Hadley:

"Your material is of a superior quality and especially adapted to the manufacture of high-class front facing brick. The color is

all that could be desired. While the brick were burned very hard in a down-draft kiln, using coal as fuel, in fact, are almost vitrified, they have still retained their shape. They have a good, clear, metallic ring, are very solid, and are equal in every respect to the famous Bradford (Pa.) brick."

Outcrops of the Knobstone shale also occur on the land of William Quinn along White Lick Creek, near Cartersburg Springs, and on Mud Creek, near Clayton.

The surface drift clays of Hendricks County are used in a number of places for making ordinary brick and drain tile.* At the James Beck yard, just south of the Big Four Railway station at Danville, the drift clay partakes of the character of a sandy loam. It is brownish yellow in color and free from lime pebbles. A well at the yard showed:

Section of Well at Beck Brickyard, Danville, Ind.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil	1	0
2. Brownish yellow drift clay.....	7	6
3. Gravel	2	0
4. Drab Knobstone shale.....	4+	0

In a ravine just south of the brickyard, about a quarter of a mile from the railway station, the Knob shale is said to come within two feet of the surface. The brick made from the drift clay are of good quality and bring \$7.50 per thousand, delivered in Danville. Sample pressed-front brick were burned from this clay for Mr. Beck by the C., B. & W. Co., of Chicago, which were of fair quality, but inferior to those made of the Knob shale.

Three miles northwest of Hazelwood brick and tile are made from a "tender swamp clay, about four feet thick," after stripping six inches to one foot of soil. At Brownsburg a surface clay three feet thick is made into drain tile, the output in 1904 being 10,000 rods. At Coatsville are two yards, in which from 24 to 30 inches of yellow and gray clay, with 15 inches of stripping above, are used in making brick and drain tile.† Near North Salem soft mud brick are made from two feet of surface clay, no stripping being necessary.

* See statistical table at end of paper.

† For additional information regarding these factories see statistical table near end of paper.

MORGAN COUNTY.

Morgan County lies just southwest of Marion County, near the center of the State, and comprises 415 square miles. It is bounded on the north by Hendricks and Marion, on the east by Johnson, on the south by Brown and Monroe and on the west by Owen and Putnam counties. Its maximum length from east to west is 24 miles and its greatest width from north to south 20 miles.

The surface rocks of the county belong mainly to the Knobstone Epoch of the Lower Carboniferous. The Harrodsburg, Bedford Oölitic and Mitchell limestones outcrop over small areas along the western margin, while the Genesee shale of the Devonian occurs beneath the drift in the northeastern corner.

In its general surface Morgan County is more diversified than the average county of the State. A belt of country some six miles wide along the north border is quite level, or, at most, not so broken as to materially interfere with cultivation. This belt is deeply covered with drift material, and its western portion comprises large tracts of black muck swamp lands, that were, 50 years ago, covered with water the greater part of the year. Ditching and tiling have, however, converted these swamps into the best of corn producing lands. Directly south of this belt, and embracing the greater part of the remainder of the county north of White River, lies a region of knobs, but little of which is level enough for profitable cultivation. The hills in some places rise 300 feet above the level of the river and are frequently so steep as to make the ascent difficult, even on foot. The surface soil of these knobs is generally clay, derived in part from the weathering of the underlying knob shales, with but a thin cover of vegetable loam above the clay. The southwestern portion of the county consists mainly of an elevated plain of clay lands, in places broken by numerous sink holes, due to the eroding of caverns by underground streams in the underlying Lower Carboniferous limestones. Some of these sink holes are 30 feet in depth and embrace half an acre of surface. The hills bordering the stream are, in this portion of the county, in many places abrupt bluffs of limestone.

In the southeastern portion of the county the surface is ele-

vated and rugged, but not so much so as to preclude its cultivation. The soil in this region close to the river is in general a sandy loam, while farther back it is a clay loam, resting on a rather hard clay subsoil, derived from the partial decay of the underlying shales. Along White River are in many places wide areas of bottom lands, which comprise the richest and most easily cultivated soils of the county. These bottoms range from one to three miles in width, and at least half their area is above the reach of annual freshets.

The West Fork of White River flows diagonally through Morgan County from northeast to southwest, and, with its tributaries, drains the entire area except the northwestern corner, from which three small streams pass westwardly into Eel River. The principal tributaries of White River from the north are White Lick, Sycamore Creek and its tributary, Gold Creek; Highland, Lambs, Burkhart's, Fall and Butler's creeks, while from the south and southeast enter Bluff, Crooked, Stotts, Clear, Indian, Little Indian and Bryant's creeks. Each of these streams has a number of smaller branches running into it, which are fed by springs. Most of them are dry in part of their courses during a portion of each summer.

The transportation facilities of the county are as yet somewhat meagre. The I. & V. Railway crosses it from northeast to southwest, the greater part of the way in the immediate valley of White River. The Fairland & Martinsville branch of the Big Four runs southeast from Martinsville and leaves the county just east of Morgantown, in the southeastern corner. The Indianapolis Southern Division of the Illinois Central—at the present writing in course of construction—will also cut across a small area of the southeastern corner. In addition to these, the Indianapolis & Martinsville Rapid Transit Co. operates an electric line between the points named in the title, which will probably soon be extended from Martinsville to Bloomington.

The surface drift clays and Knobstone shales comprise the only clay-working materials of Morgan County. The shales lie at the base of the Knobstone formation, and the best deposits will, therefore, be found in the eastern half of the county. Where workable, they consist of a thinly laminated but not distinctly stratified clay shale. This, when moist, has a pale blue color, but

when dry is of an ashen or dove-gray hue. When weathered it crumbles into a mass of plastic clay, which, if not too high in silica, makes a good burning material for all kinds of bricks.

The most available deposits of these Knob shales occur in the immediate vicinity of Martinsville and Brooklyn. On a spur of the I. & V. Railway, in the northern part of the former place, the Adams Brick Co., of Indianapolis, has one of the largest soft mud brick plants in the State. The company owns 67 acres, the main portion of which is comprised in a sloping hillside just east of the plant. From this hill surface clay and Knob shale are secured and mixed, in the proportions of one part clay to two parts shale, to make the brick. The surface clay is a fine-grained, homogeneous, brownish-yellow material, which resembles closely the noted yellow loess clays of Southwestern Indiana. Mr. Davis, the foreman of the plant, states that it is much better for brick-making than the Sheridan (Hamilton County) drift clays, the latter being "short" and cracking in drying. On the hill it lies three and a half to five feet thick over the shale. The top of the latter is 40 to 60 feet above the level of the plant. Both clay and shale are loaded into tram cars, which run by gravity, and are dumped automatically, a loaded car, while running down to the plant, pulling up an empty. About 64 cubic feet of the mixture are used in the making of each thousand brick.

The output of the plant is 40,000 daily, or 12,250,000 in 1904. These were sold as fast as burned at \$6.50 per thousand, f. o. b. the cars at the plant, or \$7.00 to \$8.00 delivered at Indianapolis, where most of them were shipped. South Linton coal, costing \$2.00 per ton for mine run and \$1.50 for slack, is mixed and used as fuel. The molding sand is secured from the Bradford deposits, near Centerton, four miles north. All the hands work by the piece or thousand brick. With the facilities at command, the brick cost about \$3.00 per thousand on board the cars at the plant. There is no waste in the Knob shale, everything being ground in the dry pan. The bats are also reground, so that the yard is free from debris. But few bricks are ever seen on the yard, as they are loaded directly from the kiln into the cars. The quality of the output is above the average for ordinary building purposes.



Plant of Adams Brick Co., Martinsville, Morgan County.



**Shale Cut on County Road, one mile northeast of Martinsville,
Morgan County.**

On the land of Branch & Son, one-half mile northwest of Martinsville, on the west side of White River, northwest quarter of section 32 (12 N., 1 E.), the Knob shale is exposed in bold bluffs, 70 feet in height. Over the shale on the top of the bluff there is but a foot of thin soil and yellow clay, but on the northwest slope of the hill the yellow clay thickens up to three or four feet and is an excellent material for ordinary brick or to mix with ground shale to insure greater tenacity for certain wares. To reach the base of the shale bluffs, a spur of the I. & V., but little over half a mile in length, would have to be built from near the west end of the railway bridge across the river.

An analysis of the shale from this point was made by Dr. Noyes, and its composition found to be:

Analysis of Knobstone Shale from Land of Branch & Son, Martinsville.

Silica (SiO_2)	70.60
Titanium oxide (TiO_2).....	.43
Alumina (Al_2O_3)	13.89
Water combined	3.19
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Clay base and sand.....	88.11
Ferric oxide (Fe_2O_3).....	2.33
Ferrous oxide (FeO).....	3.56
Calcium oxide (CaO).....	.60
Magnesium oxide (MgO).....	.50
Potassium oxide (K_2O).....	2.76
Sodium oxide (Na_2O).....	1.60
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Fluxes	11.35
Carbon dioxide (CO_2).....	.51
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Total	99.97

The analysis shows that the shale will vitrify under the proper burning, and there is no doubt but that it will make high-grade vitrified brick for street paving. It is very similar in character to the Knob shale now used for that purpose at the Poston Paving Brick factory, at Crawfordsville. Sample dry pressed front brick of fine appearance have been made from this shale for Branch & Son. They were a uniform dark red in color, hard, dense and fine-grained, with sharp edges and corners.

Farther southwest, on the land of Richard Moore, the bluffs of shale are almost as high. In the bottom of a ravine back of the

Moore residence the shale is weathered into a very tenacious, fine-grained blue clay, several feet in thickness. This is overlain with two or three feet of the characteristic yellow clay of the region.

On the land of Alex. Hedrick, near Hynsdale switch, one mile farther southwest, northeast quarter of section 2 (11 N., 1 W.), the bluffs of shale are within 120 yards of the railway, but are here more heavily covered with drift clay.

Northeast of the Branch bluffs, one-half mile above the White River bridge, a cut 400 feet long and 15 feet deep has been made for a roadway through the Knob shale. The face of the cut has everywhere weathered into small quadrangular particles, indicative of a clay shale which is not too rich in silica for manufacturing purposes. This cut is on the land of Mrs. Ed. Smith, but is more inconvenient to a railway than the deposits below the bridge.

The Knob shale is also exposed along the east side of the I. & V. Railway at a number of places just below Bethany Park. The outcrops run 12 to 15 feet above the grade, with little cover overlying.

The surface clays of Morgan County are being used for brick-making only at Martinsville by the Adams Brick Co. and John B. Clark, and at Mooresville by the Bradley Brick Co. The Adams Brick Co.'s yard has been mentioned above. That of Clark, just to the south, is a small hand yard, with an output of about a half million per year. The clay used is the yellow sandy loam, six to eight feet thick, which occurs on the slopes of the hill to the east.

At the Mooresville yard the brick are made from a bluish-gray drift clay, about three feet in thickness, with little or no stripping. An analysis of an average sample of this clay, Lyons, chemist, shows its constituents to be as follows:

Analysis of Drift Clay used for Ordinary Brick Making at Mooresville.

Silica (SiO_2)	73.97
Titanium oxide (TiO_2)91
Alumina (Al_2O_3)	12.33
Water combined	3.16
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Clay base and sand	90.37

Ferric oxide (Fe_2O_3).....	3.87
Calcium oxide (CaO).....	.76
Magnesium oxide (MgO).....	.78
Sodium oxide (Na_2O).....	4.23
Potassium oxide (K_2O).....	trace
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Fluxes	9.64
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Total	100.01

The plant at Mooresville is new, having been erected in 1904, in time to be operated only about four months. The clay seems well fitted for ordinary brick-making.

By the side of the Big Four Railway, on the land of Mrs. Abrilla Merriman, about three miles south of Martinsville, south-west quarter of section 14 (11 N., 1 E.), occurs a deposit of a very fine-grained buff to drab marly clay, 10 to 18 feet in known thickness, with two to three feet of surface soil and clay above. The upper part of the deposit, which is in a hill or knoll of about ten acres, is buff, the middle portion drab and the lower portion a slate blue in color. The clay resembles a marl loess, and is free from lime pebbles and other impurities. Its chemical composition, as determined by Dr. Lyons, is as follows:

Analysis of Clay from Land of Mrs. Abrilla Merriman.

Silica (SiO_2)	49.51
Titanium oxide (TiO_2).....	.87
Alumina (Al_2O_3)	14.73
Water combined	3.59
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Clay base and sand.....	68.70
Ferric oxide (Fe_2O_3).....	4.65
Lime (CaO)	9.48
Magnesia (MgO)	3.76
Potash (K_2O)68
Soda (Na_2O)	2.41
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Fluxes	20.98
Carbon dioxide (CO_2).....	10.72
<hr/>	
Total	100.40

The analysis shows the clay to be very high in fluxes. It will probably burn a buff color, and can be made into drain tile and ordinary brick, but would fuse before the point of vitrification is reached. It could be used for terra cotta lumber, such as is made

at Hobart and Brooke, Ind.,* from a mixture of four-fifths clay and one-fifth sawdust. There is a constantly growing demand for this kind of fireproofing, and a plant located in central Indiana would have good market facilities. A plentiful supply of water is present within 150 yards of the hill or knoll in which the clay occurs.

A clay of similar composition, but dark gray in color occurs over an area of 15 or more acres on the land of J. C. Wilson, two miles south of Paragon, southeast quarter of section 30 (11 N., 1 W.). It is covered with surface clay two to four feet thick, and a bore 12 feet deep has been sunk into it without finding its bottom.

BROWN COUNTY.

The northern boundary of this county is about 30 miles nearly due south of Indianapolis. The county is bounded on the east by Bartholomew, on the south by Jackson and Monroe, on the west by Monroe and on the north by Morgan and Johnson counties. It is quadrangular in shape, 20 miles long from north to south, 16 miles in width from east to west, and contains an area of 320 square miles. With the exception of fragments of the reddish crinoidal Harrodsburg limestone on a few of the higher ridges, the surface rocks of the county are wholly the soft sandstones and shales of the Knobstone Epoch of the Lower Carboniferous Period. For that reason they have been easily eroded, and the county is very broken, except in the southeastern corner, where there is a large area of level tableland. The "Knobs" of Southern Indiana, stretching northward from Floyd County, attain, in "Weed Patch Hill," south of Nashville, the county seat, their highest elevation—1,147 feet above sea level.

Salt Creek, the principal stream of Brown County, is composed of three main branches—the "North," the "Middle" and the "South" forks—which unite near the southwest corner of the county and flow thence through Monroe and Lawrence into East White River. Thus almost the whole watershed of the county, together with a considerable portion of Jackson, on the south, is drained by this stream. Bean Blossom Creek has its source in the northeastern part, its principal tributaries in northwestern Brown

* See under "Clays of Lake and Newton counties."

being Bear and Lick creeks, both flowing nearly south. Just across the northern boundary, in Morgan County, and in a valley nearly parallel with the county line, is Indian Creek, flowing in a general westerly direction.

High ridges surround the county on all sides, while from east to west and southwest three similar ridges traverse the county, all connecting on the divide near Trafalgar, in Johnson County. The first and the most northern constitutes the southern bluff of Indian Creek, and is called "Indian Creek Ridge;" the second, south of Bean Blossom, is known as "Bean Blossom Ridge," and the third, passing nearly through the middle of the county, is named "Central Ridge." All these ridges slope gently to the south and west, but present steep faces to the north and east. The valleys of the county, now containing its richest soil, have been eroded by flowing streams, leaving the strata of the hills as they were originally deposited by sedimentation in an ocean which covered this region ages before the dawn of the "Glacial Period."

Only the northern third of Brown County is within the glaciated or drift area. The northwestern part of Hamblin Township and the greater portion of Jackson Township are covered with drift accumulations as far south as Bean Blossom Ridge, the drift being found on the slope of this ridge nearly 200 feet above the water in the stream. Boulders of granite, gneiss and jasper, three to five feet in diameter, occur frequently in this region. In the Salt Creek Valley, northeast of Nashville, but little drift was seen. Bean Blossom Ridge, then, marks the southern limit of the first and only glacial invasion of the county.

Collett, in his "Report on Brown County,"* says: "Against and upon this wall-like ridge the stranded ice seems to have been continually massed, and, melted by each recurring summer's sun, it sent torrents of water south across the county, wearing slight depressions in the ridges, as at Low Gap and the source of Greasy Creek, bearing fine sediment, some gold dust and black sand, and but few or no pebbles or boulders. This flood was long continued, first flowing clear across the county at a high level, and even across parts of Jackson; next following the synclinal axes of the

* Geol. Surv. of Ind., 1874, pp. 77-110.

underlying rocks, it excavated South and Middle Forks of Salt Creek, and, finally following another synclinal, adopted the direct line of dip by the North Fork. During this time the underflow from the glacier was also working a channel in the disintegrating shale along the east side of the county, by Bean Blossom, and finally left the interior basin of the county subject only to the action of its own watershed."

Brown County has, up to the present, been without railway facilities, but the Indianapolis Southern Division of the Illinois Central, now being built, will cut across a portion of its north-western corner. The only deposits of shales and clays in the county examined for this report were along the partially finished grade of that railway.

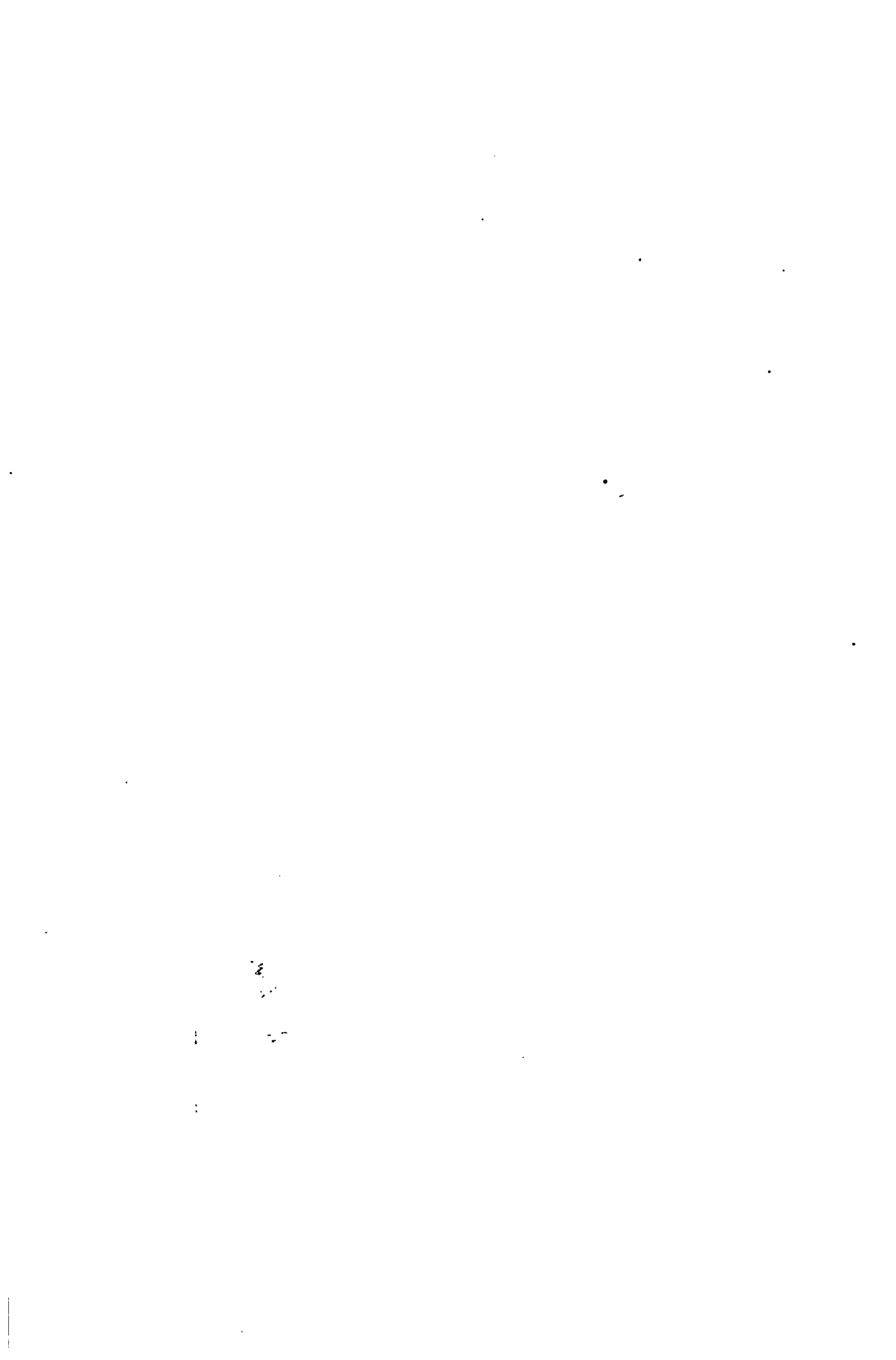
At the O'Connor cut, 31 feet deep, three miles southwest of Morgantown, in the northeast corner section 1 (10 S., 2 E.), the shale is exposed 10 feet thick beneath a heavy cover of yellow clay and hardpan. Between the hardpan and the shale, and resting on the top of the latter, is a three-foot stratum of stiff, brownish clay, which contains many fragments of cedar logs. This clay probably represents a portion of the old pre-glacial soil which covered this area before the ice sheet came and left the heavy cover of overlying till.

Along the roadways and slopes in the southeast quarter section 12 (10 N., 2 E.), the ashen gray Knob shale occurs within a foot or two of the surface, and outcrops in the ditches and shallow ravines. Many of these outcrops occur within a half mile of the railway grade.

The shale is exposed in the bottom of the North Fork of Bean Blossom, at the point where the north-south wagon road strikes that stream, in the northeast quarter of section 13. It is here covered with two to five feet of gravel and clay, and but a few rods from the railway.

Farther west, at the James Harris cut, northwest quarter of section 18, the shale, two to four feet thick, is overlain with three to five feet of yellow clay and underlain with a heavy ironstone band.

Sixty yards north of the point where the railway crosses the North Fork, in the southeast quarter of section 24, is a shale ex-





**Two Outcrops of Knobstone Shale along the Indianapolis Southern
Railway in Brown County.**

posure 20 feet thick, with two layers of iron carbonate about three feet apart, the upper one, four inches thick, being six feet from the top of the shale. A similar layer of ironstone forms the floor or bed of the stream at the point where crossed by the railway.

One and a half miles farther southwest, in the northwest corner of 35, a cliff of shale occurs on the south side of and about 80 yards distant from the railway. This exposure is 24 feet thick, with two to four feet of yellow clay and gravel above. Two thin layers of iron carbonate occur in the shale stratum about eight feet from the top.

On the Jenkins farm, about two miles northeast of Needmore, in the southwest quarter of section 28, a bold cliff of the shale, 70 feet and more in height, occurs on the south bank of Bean Blossom Creek. The talus from this cliff has banked up against its foot and forms a slope covering one-third its height. This talus or debris has weathered into a fine-grained, plastic clay, which appears suitable for the clay ingredient of Portland cement. The shale at this point appears less siliceous than that farther east, and there is no doubt but that it will make either ordinary or dry pressed front brick, or good vitrified street brick. The creek will furnish an abundance of water, and the railway is but 150 yards to the north. This was the best grade of the Knob shale seen in Brown County, but a closer inspection and practical tests will doubtless show that a number of the outcrops farther east are of workable quality for dry-pressed or vitrified brick-making. It is doubtful if any of them can be used for making hollow vitrified products, as in general the Knob shales are too lean for that purpose.

The railway passes through a low cut just north of the high shale cliff above mentioned, whose sides, to a depth of three feet, are composed of a light yellow, fine-grained loess clay, wholly free from lime pebbles and other impurities, and suitable for a good grade of ordinary brick, drain tile or pressed front brick.

No factory for making brick, drain tile or other article of clay exists in Brown County.

JACKSON COUNTY.

Jackson County lies in the southern third of the State, and about midway between its eastern and western borders. It comprises an area of 520 square miles, and is bounded on the north by Brown and Bartholomew, on the east by Jennings and Scott, on the south by Scott and Washington, and on the west by Lawrence and Monroe counties. It is rectangular in shape, but its southern boundary is very uneven, due to the meanderings of the Muscatatuck and White rivers, which form that boundary line.

The Knobstone rocks cover the surface of nearly the entire county, their eastern horizon being nowhere more than six miles west of the Jennings County line. To their east the Black Shale of the Genesee Epoch lies next below the surface soil and clay.

The East Fork of White River enters the county three miles west of its northeastern corner, and, flowing southwesterly, divides its area into two triangular-shaped districts, which are very unlike in their topography and in the character of their soils. In the southeastern district the surface is mostly rolling, with low, sandy hills, 50 to 100 feet in height. The northwestern district is very broken, and is traversed by a number of ridges and their intervening, steep-sided, V-shaped valleys. The ridges rise from 250 to 300 feet above the plains of White River. Both ridges and valleys trend in a northeasterly and southwesterly direction. The valleys are unproductive, except where bottom lands have been formed in them by the silting-up process. In this region the descent from the highest Knobstone hills to the lowlands to the south is gradual, and across rolling foothills which merge into low glacial hills, and finally into the low bottom lands of East White River. In places the foothills spread out into broad table lands, which possess a sub-soil of clay.

Few counties in the State can boast of a better agricultural region than that found in the southeastern district and along the immediate valley of White River. No better crops of corn, oats and melons are produced in Indiana than are grown on the first and second bottom lands west of Seymour, while the sandy loam soils of the southern part of the county are especially adapted to the raising of peaches and grapes.

White River is, of course, the main drainage stream of the

county, and receives numerous small tributaries from either side. The Muddy Fork of Salt Creek has its source in the valleys of the northeast quarter, and drains that region, while the Muscatatuck and its main, or Vernon Fork, drains the southeastern corner.

The railway facilities of the county are good. The J., M. & I. Division of the Pennsylvania Railway passes north and south through the eastern third. The B. & O. S.-W. crosses diagonally from northeast to southwest, while the Southern Indiana runs east and west a few miles north of the center. All three converge at Seymour, the leading town of the county.

The clays of Jackson County which are sufficient in quantity and of suitable quality for extensive manufacturing are surface clays and the Knobstone shales, which outcrop along White River southwest of Seymour and on the sides of a number of the ridges west and northwest of that city.

On the roadside, one-fourth mile east of White Creek, in the northwest quarter of section 32 (7 N., 5 E.), is an outcrop of grayish soapstone or clay shale, very fine-grained, wholly free from grit, and, where weathered, very soft and plastic. It is overlain by a boulder clay from three to 10 feet in thickness, from which it is separated by a thin stratum of carbonate of iron. This shale deposit is about three miles north of the Southern Indiana Railway. There is no doubt but that it could be made into paving brick of excellent quality. It will also make pressed front brick, roofing tile and sewer pipe.

One-half mile farther west, in the northeast quarter of section 31 (7 N., 5 E.), on the farm of the late Hon. Louis Schneck, a brick and tile factory was in operation for ten or more years. The brick were made from a buff, loamy clay, evidently of glacial origin, the deposit of which covers 30 or more acres to a depth of 13 feet, and overlies a stratum of sand 12 feet in thickness. But five feet of the clay were used, since below that depth lime pebbles appear. These are not so many, however, but that they could be crushed with a dry pan and their harmful tendencies thus destroyed.

From this clay end-cut brick were made on a Frey-Sheckler auger machine, which were used for paving alleys and street crossings in Seymour a number of years ago. They have since

been subjected to much heavy traffic, but as yet show no signs of wear.

A square down-draft kiln was used in burning these brick, and a handsome dark glaze was formed on their surface without the use of salt or other artificial substance. By mixing this surface clay with the above-mentioned shale, one-half mile distant, in the proportion of two parts of the former to one of the latter, and then making the brick on a side-cut machine and burning in a standard round, down-draft kiln, there is little doubt but that paving brick of unexcelled quality would result. At present, however, the deposit is too far from transportation facilities and fuel to carry on the business on an extensive scale.

A deposit of soft clay shale, suitable for vitrified products, outcrops on the roadside in the southeast quarter of section 1 (6 N., 4 E.), one mile west and two south of the brick factory above mentioned. It is 10 feet in thickness where exposed and is overlain by boulder clays.

West of the station of Surprise, in the northwest quarter section 9 (6 N., 4 E.), there is an exposure of Knobstone shale in a ravine a few rods south of the S. I. Railway. This bed of shale covers a large area in the ridges to the south, and is capped with a thin covering of soil, boulder clay, iron carbonate and geodes. The exposure is 15 feet in thickness, but the total thickness of the deposit was not determinable. It weathers into a soft, plastic, grayish clay. One hundred yards farther west the same shale is cut to a depth of 17 feet by the railway, and is overlain with three feet of a mixture of the materials above noted.

One mile a little south of west of the above exposure and 150 yards south of the Southern Indiana, on the land of John W. Lucas, east half section 7 (6 N., 4 E.), a bold bluff of the Knobstone shale rises 40 or more feet above the water of Salt Creek at its base. In this bluff are four parallel layers of large concretions of ironstone (siderite). One of these layers is about three feet above the surface of low water. Six feet higher is a second, eight feet higher a third, and two feet higher a fourth. Some of these concretions are flat, several feet across and six to ten inches thick. Between these layers of ironstone the shale weathers in small quadrangular blocks. This Knobstone shale is called "soapstone" by the residents of that vicinity, but, as already noted, the

term "soapstone" rightfully belongs to the mineral steatite or talc, a magnesium silicate which does not occur in Indiana.

A partial analysis of samples from the above outcrop of shale, made by F. E. Walker, chemist of the U. S. Cement Co., of Bedford, showed the presence of the following constituents:

Partial Analysis of Knobstone Shale from near Freetown, Ind.

Silica (SiO_2)	59.70
Alumina (Al_2O_3)	21.87
Ferric oxide (Fe_2O_3)	6.59
Lime (CaO}) .....	.95
Magnesia (MgO)	2.27
Loss (alkalies, etc.)	5.44
Total	96.82

The analysis proves the shale well fitted for the clay ingredient of Portland cement.

All of the deposits of this shale east of Freetown, if properly weathered and then ground fine, will be found in every way suited for making vitrified products. In the bluffs above mentioned, and in others farther down the stream in the same and adjacent sections, they are found in practically inexhaustible quantities. Their proximity to a railway and to a good supply of water can not be excelled. The only thing lacking is a fuel supply, which can be readily and cheaply obtained from the coal regions to the westward through which the railway passes.

West of Freetown, between Norman and Kurtz, are a number of deep cuts in which the shale is exposed 25 to 40 feet above the railway grade. Those east of Kurtz are of seemingly good quality for manufacturing purposes, but west of that station they partake more of the nature of shaly sandstones, and are probably too high in silica for anything but ordinary brick-making.

South of Freetown, in sections 18, 19 and 30 (6 N., 4 E.), many outcrops of the Knobstone shale occur in the hillsides. In general, they are overlain with layers of geodes and ironstone clays. The latter, when exposed for some years to rain and frost, weather into small quadrangular brownish pieces, called "creek gravel." This is often used in repairing roads, since but little true drift or water-worn gravel is found in the region.

The best-known exposure of Knobstone shale in Jackson

County is that now furnishing the clay ingredient for Portland cement at the large Lehigh Portland Cement factory, at Mitchell, Ind. This deposit is at a point called "Blue Lick," on the south side of the B. & O. S.-W. Railway, in the northeast quarter of section 6 (5 N., 5 E.). A description and analysis of this shale was published on page 146 of the 22d (1897) Report of this Department, and from that description the promoters of the Lehigh factory first gained a knowledge of the presence of a shale suitable for their needs within easy shipping distance of the proposed factory.

The Blue Lick deposit is exposed from 10 to 60 feet above the level of the railway, and is covered with from 2 to 12 feet of sand. It consists of a soft, fine-grained, argillaceous variety of the Knobstone shale; is wholly free from grit and lime impurities, contains but few concretions of ironstone, and weathers into a soft, unctuous, plastic clay. It outcrops along a ridge for a distance of several hundred yards, and forms the main body of the ridge throughout its full width. The railway formerly ran at the very foot of the outcrop, but the shale weathered and fell down over the track to such an extent that the latter had to be moved several rods to the north.

The analysis of the shale, Noyes, chemist, showed its composition to be as follows:

Analysis of Knobstone Shale from "Blue Lick," Jackson Co.

Silica (SiO_2)	59.64
Titanium oxide (TiO_2)	1.05
Alumina (Al_2O_3)	19.14
Combined water	4.36
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Clay base and sand	84.19
Ferric oxide (Fe_2O_3)	3.39
Ferrous oxide (FeO)	4.20
Lime (CaO)26
Magnesia (MgO)	2.31
Potash (K_2O)	3.53
Soda (Na_2O)80
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Fluxes	14.49
Carbon dioxide (CO_2)35
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Total	99.03

The analysis shows a very close approximation to the standard of comparison (see p. 82), and proves the chemical fitness of the shale for the making of paving brick and sewer pipe. In 1904 approximately 44,000 tons were used at the Mitchell cement factory, the output of the factory being 1,900 barrels of cement per day, one-third of which was shale. The Lehigh Company has begun a new factory just east of the present plant, which will have a capacity of 3,000 barrels per day. When completed the Blue Lick deposit of shale will furnish the clay ingredient for both plants.

Shales of the same character as found at Blue Lick occur at various points from Brownstown to four miles east along the south side of the B. & O. S.-W. Samples have been received from the Brownstown Brick & Tile Co. which had partly weathered into a soft blue-gray gritless, plastic material of high grade for either Portland cement making or vitrified clay wares. In the accompanying letter it was stated that "The stripping consists of sand from one foot to ten in thickness. The shale is known to be 100 or more feet thick."

Just northeast of the Blue Lick deposit, in the southeast quarter of section 31 (6 N., 5 E.), is a tract of 50 acres by the side of the railway, on which the shale is also of good quality for cement making or vitrified materials. This tract is owned by Matthews & Chrisler of Bedford. The stripping above the shale is of a sandy nature, and so shallow that holes dug for fence posts enter the latter. An analysis of the shale made by Dr. Noyes showed its composition to be very similar to that of the Blue Lick deposit.

Analysis of Knobstone Shale from Land of Matthews & Chrisler, east of Brownstown.

Silica (SiO_2)	59.95
Titanium oxide (TiO_2).....	1.12
Alumina (Al_2O_3)	18.65
Water	4.54
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Clay base and sand.....	84.26
Ferric oxide (Fe_2O_3).....	4.87
Ferrous oxide (FeO).....	3.34
Calcium oxide (CaO).....	.34
Magnesium oxide (MgO).....	2.18

Potassium oxide (K_2O).....	3.57
Sodium oxide (Na_2O).....	.78
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Fluxes	15.08
Carbon dioxide (CO_2).....	.28
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Total	99.62

The analysis proves the chemical fitness of the shale for the uses above mentioned.

West of Brownstown the Knobstone shales outcrop in the vicinity of Medora in places in bold bluffs or hills near to and on the north side of the B. & O. S.-W. Railway. These western deposits are higher in silica than the Blue Lick deposit, and therefore not so suitable for Portland cement making. On the land of D. M. Hughes, just northeast of Medora, northeast quarter section 27 (5 N., 3 E.), and about three-quarters of a mile from the railway, is a high hill composed of the shale, the latter being overlain with soil and yellow clay, two to three feet in thickness. An analysis of samples of the shale by Dr. Noyes showed the presence of the following constituents:

Analysis of Knobstone Shale from Land of D. M. Hughes, near Medora.

Silica (SiO_2)	64.59
Titanium oxide (TiO_2).....	.30
Alumina (Al_2O_3)	16.37
Water combined	3.71
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Clay base and sand.....	84.97
Ferric oxide (Fe_2O_3).....	5.37
Ferrous oxide (FeO).....	1.59
Lime (CaO)16
Magnesia (MgO)	1.56
Potash (K_2O)	4.24
Soda (Na_2O)97
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Fluxes	13.89
Carbon dioxide (CO_2).....	.43
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Total	99.29

The analysis proves its fitness for making ordinary pressed front or paving brick. Sample pressed front brick made from it were of a high grade. A company with \$30,000 capital was organized in 1904 for utilizing this deposit for the making of such

brick. The land at the base of the shale deposit is level and easy of access by the railway, thus furnishing a good site for a large factory.

At Seymour several million brick have been brought from Ohio and laid down in the streets. These cost from \$10.00 to \$14.00 per thousand. The raw material for making them was to be found in abundance by the side of the railway within five miles of the spot where they were used. The extra amount paid for transportation of these brick would have paid for a good plant for manufacturing them, which, in the future, would have furnished labor for many hands. No paving brick factory exists at present in Southern Indiana except the one at Evansville. All the towns of a thousand or more inhabitants in that region will, within a few years, use brick for paving their leading streets. No cheaper or more durable pavement can be put down. All things considered, no better point exists for locating the factory to supply the brick for these future pavements than at one of the various points above mentioned along the S. I. and B. & O. S.-W. railways in Jackson County.

Ordinary brick and drain tile are made from the surface clays of Jackson County at Seymour, Brownstown, Kurtz and Crothersville.*

At Seymour three to six feet of surface clay are used, and about 1,000,000 brick made each year. At Brownstown 6 to 18 inches of sandy soil is first stripped and the underlying clay, three to six feet thick, is made into brick and drain tile, the value of the output in 1904 being \$2,700.

At Kurtz eight feet of yellow clay and "soapstone" are used, after removing one foot of soil. Both brick and drain tile are made, but the output is small, being valued only at \$1,462 in 1904. At Crothersville the surface soil and clay, both of which are used, are two and a half feet thick. Below this occurs a "joint clay" not suitable for working. About 300,000 brick were made in 1904. Those brought \$5.00 per thousand at the plant.

*See statistical table near end of paper.

WASHINGTON COUNTY.

Washington County lies near the center of the southern third of the State. It is separated from Lawrence and Jackson counties on the north by the East Fork of White River, and its largest tributary, the Muscatatuck River. On the east it is bounded by Scott and Clark, on the south by Floyd, Harrison and Crawford, and on the west by Orange and Lawrence counties. The county is one of the larger ones of the State, being 25 miles in extreme width from north to south and 25 miles in greatest length from east to west, its area being 523 square miles.

The rocks of four Geological Epochs of the Lower Carboniferous Period form its surface. These are the Knobstone, covering the greater part of the northern fourth and eastern third of the county; the Harrodsburg Limestone, occurring on the higher hills and ridges east and north of the center; the Bedford Oölitic limestone, occupying narrow, tortuous areas in the central third and northwestern fourth, and the Mitchell limestone, covering the greater part of the western third. A few outliers of the Huron Group also occur in the southwestern portion.

From the vicinity of Salem westward to the county line, especially along the line of the Monon Railway, the surface of the county is generally level, or nearly so. This area comprises the better agricultural portion of the county. The northern and eastern parts of the county are broken and rough. Going westward or southward from the Muscatatuck River, the upper part of the Knobstone is approached. This has a larger proportion of sandstone and is capped by the hard limestones of the Harrodsburg Epoch. These withstand erosion much better than the lower members of the Knobstone and give rise to a belt of country of extremely broken character. The hard overlying limestones tend to form a high plateau sloping to the west with the dip of the rocks. The eastward and northward flowing streams have eaten through this overlying crust, where it is thinning out along its edge, and once through that and the hard sandstones in the upper part of the Knobstone formation, they have cut rapidly through the soft underlying shales nearly to the base level of the region to the east. The result is a series of valleys from 250 to 300 feet deep and from one to five miles long, separated by

narrow divides. The divides tend to be flat-topped, evidently being uneroded prolongations of the plateau. As they extend out from the plateau they tend to become narrower and to have low saddles cut in the crest, and finally the ridge ends abruptly, making a bold headland, to which the name "knob" has been given. The central and southern parts of the county are, in many localities, considerably broken, but the land is not so rough as much of the north and east.

The creeks of the northern part of the county flow a northerly course, with a slight trend to the west, and empty their waters into the East Fork of White River or the Muscatatuck. Named in order from the west, they are Clifty, Twin, Rush, Buffalo, Delaney and Elk creeks. All of the eastern and southern portions of the county are drained by Blue River or some of its many branches, its principal tributaries in the county being the North, Middle and South forks. These unite near Fredericksburg, close to the south county line.

The transportation facilities of the county are poor, the C., I. & L. (Monon) being the only railway within its bounds. This crosses the country in a northwest-southeast direction, passing through Salem, the county seat.

The deposits of available commercial clays in Washington County are few and far between. The Knobstone shales, in the northeast part of the county, will, in many places, be found suitable for clay wares or for the clay ingredient of Portland cement, but they are at present too distant from railway facilities to be of value. In the outcrop nearest Salem the percentage of silica present will be found much higher than in those farther northeast, where the clay shales predominate. Whether the silica will run too high to allow the use of the shale for making Portland cement only chemical analyses will show.

The dark blue, clayey, New Providence shales, which lie at the base of the Knobstone formation in the northern part of the county, run from 150 to 200 feet in thickness, and contain many concretions of iron carbonate. These shales are low in silica and everywhere suitable for manufacturing. They are overlain with 80 feet or more of siliceous shales, and these, in turn, by 10 to 60 feet of grayish to buff Knob sandstone. The blue, clayey shales outcrop in many places along Delany's Creek near its mouth. At

Plattsburg they are exposed to a thickness of more than 100 feet.

Gibson Township is the principal Knobstone region of the county, the knobs or ridges rising in places 300 feet above the creek bottoms. The New Providence shales abound along Elk Creek, in some places on the west bluffs being exposed to a thickness of 220 or more feet. Four or five miles above the mouth of Elk Creek the "knobs" rise to a height of more than 300 feet above the creek bottom. The exposures show blue shales all the way to the tops. Should a railway ever be built in this section of the county a plentiful supply of clay-working material can be easily and cheaply secured.

In the townships of Franklin and Polk the main exposures of Knobstone shales are in the cuts made by the creeks and branches, but these are so numerous that it is not difficult to find the outcroppings of these rocks in any neighborhood. Along the Middle Fork of Blue River, from the vicinity of New Philadelphia almost to the point where the stream is crossed by the Monon Railway, the Knobstone shales may be seen at many points. They underlie the Harrodsburg limestones and are of a uniform, dull, blue color, soft and pyritous, and crumbling rapidly on exposure. Good deposits for brick-making could probably be found in the vicinity of Farabee and Pekin stations, but on account of a lack of time no investigation of these localities was made.

On the old Rodman farm, one mile east of Harristown, is an exposure of the blue shale, 35 feet in thickness, but overlain with 80 or more feet of sandstone and limestone.

The outcrops nearest Salem are about two and a half miles east along the North Fork of Blue River. Eight to ten feet of the shale, overlain with yellow clay, are here exposed in a cut on the Canton road. Northeast of Canton, about one and a half miles, the shales may be seen outcropping along the perpendicular banks of a small creek. At both places they can be made into vitrified, pressed-front or ordinary brick.

Ordinary brick are made from surface clay in Washington County only at Salem, and drain tile at Little York, near the eastern boundary. At the latter place a "low bottom" alluvial clay is used for drain tile-making.

FLOYD COUNTY.

This is a small, triangular county, in the southern part of the State, lying on the Ohio River, opposite Louisville, Ky. It lies south of Clark and Washington, west of Clark and east of Harrison and Washington counties. Its greatest length from north to south is 15 miles and its maximum width 14 miles. However, on account of its shape, it contains but 150 square miles, being the second smallest county in the State.

The surface rocks of the county belong to five Geological Epochs, viz., the Genesee shale of the Devonian, the Knobstone and the Harrodsburg, Bedford Oölitic and Mitchell limestones of the Lower Carboniferous Periods. The black New Albany or Genesee shale covers only a narrow strip in the southeastern corner. The Knobstone shales form the surface of the greater part of the eastern half, while the Lower Carboniferous limestones occur in the western half.

The surface of the county is diversified with hills and valleys, bottom lands along the streams and considerable stretches of level and rolling country. A range of knobs, the Silver Hills, runs through the county from north to south, the elevated surfaces of which constitute some of the best fruit lands in the State. The soil and climate are well adapted to all kinds of fruit, especially grapes. The valleys and bottom lands of the Ohio are proverbial for fine crops of corn, wheat, oats, rye and barley, the soil being of a deep black loam or, in some parts, loam mixed with clay, and in others with sand and gravel, lying favorably for natural drainage, and, consequently, dry and easily tilled.

Transportation facilities in the southern and eastern portions of the county are good, but in the northern and northwestern parts are wholly lacking. The Ohio River, which forms the southeastern border for a distance of ten miles, furnishes a cheap and ready outlet by water. The C., I. & L. (Monon) Railway runs north and south, close to the eastern edge, while the St. Louis Division of the Southern Railway crosses the county from east to west, a little south of the center. In addition to these, spurs of the J., M. & I. and B. & O. S.-W. pass through New Albany in reaching Louisville.

The best and most available commercial clays of Floyd County

are the New Providence shales, lying at the base of the Knobstone formation, in the immediate vicinity of New Albany. In 1873 Prof. Borden wrote of these shales as follows: "The Knobstone formation constitutes the broken range called 'Silver Hills,' which extend from a point on the Ohio River below New Albany to the northern line of Clark County. At the latter locality the range is called the Guinea Hills. The knobs, as their names imply, rise abruptly from the black slate to a height of four or five hundred feet above the general level of the country.

"The New Providence shale lies at the base of the knobs, immediately above a ferruginous limestone, and has a thickness from 80 to 120 feet. As you follow the line of the knobs to the northwest it becomes thinner until, at the Guinea Hills, it is only 50 to 60 feet. It is a fine, greenish colored marly shale, that pulverizes when dry without difficulty. As many as six to ten bands of carbonate of iron have been found in this formation in a vertical space of about 20 feet. The lower band is usually on a level with the drainage of the country. These bands will average from four to six inches in thickness, and are separated from each other by two to four feet of soft shale. They have a great persistency, and may be seen cropping out along the side of all the ravines.

"The New Providence shale is well exposed below New Albany at the base of the knobs. In this locality, as well as along the Corydon Pike, it attains its full thickness. Trestle No. 6 of the Air-Line (now the Southern) Railway rests upon its summit, and Trestle No. 1 is at its base, and the thickness is here more than 100 feet. About the usual quantity of kidney ore is found also in it at this locality, but the stratified ore does not occur here as it does farther north in Clark County."

These Knobstone shales are being made into ordinary brick at two large factories just west of New Albany, near the side of the Southern Railway. The largest and oldest of these plants is that of the Hoosier Brick Co., erected in 1894, for making stiff mud brick from a deposit of shale, on the south side of the railway, about two miles west of the city. For a time these brick were sold largely for alley and crossing pavements, not being deemed hard enough for street paving under heavy traffic. This was, however, more the fault of the burning than of the material. In recent years about 70 per cent. of the output has been sold for

building purposes and 30 per cent. of the harder brick for gutters and alleys. The former bring \$6.00 and the latter \$7.00 per thousand f. o. b. the cars at the plant.

The shale pit, in September, 1904, had an exposed face of 60 feet, the upper third being drab in color, the lower two-thirds light blue. Occasional nodules of iron ore (siderite) were scattered through the shale. One layer, four inches thick, was present about 12 feet above the floor of the pit. The level of this floor was about ten feet above that of the yard and plant. A well just north of the plant and at its level was sunk 70 feet into the shale before reaching its bottom. In a few places thin layers or encrustations of selenite (calcium sulphate) occur between the shale layers. When this is burned it causes a white efflorescence on the brick, which lessens their value. The stiff mud brick made from this shale are bright cherry red in color and of good quality. Those which are wholly or partly vitrified are a uniform dark red, very hard, tough and non-porous. Burned in the proper kind of kilns by men of experience, the shale could be made into a good quality of vitrified street brick. The softer and more plastic portions of the deposit could also be used for hollow building block.

From an exposure in the hills just west of the Hoosier plant the Kentucky Vitrified Brick Co., of Louisville, have shipped a quantity of the shale for use in their factory. Two parts of the shale were mixed with one part of under-clay from Kentucky for making vitrified street brick. The shale was tested for sewer pipe, and made a good body, but, it is claimed, would not glaze properly with salt.

About midway between New Albany and the plant of the Hoosier Brick Co. is the new plant of the Goetz Pressed Brick Co., erected in 1903-1904 for making dry-pressed brick from the Knobstone shales. It is located on a spur of the Southern Railway, just north of the main line. The shale is obtained from a pit on the north side of the Corydon and New Albany Pike, about 15 rods northwest of the plant, being carried to the latter in tram cars which run by gravity. The pit, where worked in September, 1904, showed 18 feet of soft drab to blue clayey shale, but the latter rose to the north in a gradual slope to fully 100 feet above the level of the pit bottom. The surface of this slope was much cut up by erosion, and where bare of surface clay the top of the

partially weathered shale was in places covered with numerous small particles of iron carbonate. These, farther north, in Clark and Jackson counties, are termed "creek gravel," and are much used as road material.

There is little or no stripping above the shale at the Goetz pit, and the exposed shale had everywhere weathered into small quadrangular blocks, indicative of its plasticity. Only an occasional nodule or concretion of iron ore was visible. The upper 15 feet was drab to dove-gray in color and somewhat stained with iron oxide, both hue and stain being due to the leaching of centuries. The lower three feet of the exposure was light blue, that being the natural color of the unweathered material. About 70 cars, holding a ton each, were used each day in making 25,000 brick. Six men were required in the pit to excavate this amount. The material was being ground and mixed in the proportions in which it occurred in the pit. An analysis of an unburned brick, picked at random, was made by Dr. Lyons, and the composition found to be as follows:

Analysis of Knobstone Shale used at the Goetz Pressed Brick Factory.

Silica (SiO_2)	63.88
Titanium oxide (TiO_2)91
Alumina (Al_2O_3)	17.85
Water combined	4.99
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Clay base and sand	87.63
Ferric oxide (Fe_2O_3)	5.38
Lime (CaO)38
Magnesia (MgO)	1.47
Soda (Na_2O)	1.29
Potash (K_2O)	3.98
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Fluxes	12.50
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Total	100.13

The analysis proves the chemical fitness of the material for ordinary dry-pressed or vitrified brick; also for the clay ingredient of Portland cement.

The same grade of Knob shale is exposed close to the surface along both sides of the Southern Railway between the Goetz plant and the tunnel, and this locality offers suitable sites for a number of factories, which could use the shale for many products.



Weathered Slope of Knobstone Shale, above Pit of Goetz Pressed Brick Co., New Albany, Floyd County.



Knobstone Shale Pit of Goetz Pressed Brick Co., New Albany, Floyd County.

On or near the Monon Railway, north and northeast of New Albany, almost as far as New Providence, the same shale is exposed in inexhaustible quantities. One of these outcrops is on Falling Run Creek, near the end of Vincennes Street, and but three or four squares from the railway. A mile farther north is an extensive deposit, the surface of which is 25 feet above the railway grade. Still another is on the land of Thomas C. Hanna, one-half mile farther northeast. Since the shale holds water like a cistern, large surface ponds would furnish a plentiful supply, or it could be secured from the river or the city waterworks. On account of competitive rates on the river, coal is sold at New Albany at very low prices. All these factors, coupled with the excellent transportation facilities offered by the four railways and the river, make the vicinity a most inviting one for prospective clay manufacturers.

Aside from the brick plants above mentioned, the only clay industry at present in Floyd County is that of Henry Vance, located about two and a half miles north of New Albany. From the Huntingburg potters' clay, already described,* he makes a "stone pump," which has a high reputation through Floyd and adjoining counties. The cylinder of the pump is three inches and the suction pipe one and a quarter inches in diameter. Both body and heads of the latter are pressed out from one piece of clay by a device patented by Mr. Vance. In most other factories the heads are welded to the body. Through these heads pass bolts which fasten the different sections together. The plant has been in operation 17 years, and the value of the output is about \$7,000 per annum.

(b) *Clays of the Counties Comprising the Lower Carboniferous Limestone Area.*

The area covered by the Lower Carboniferous limestones lies southwest of the center of the State, between the Mansfield Sandstone of the Carboniferous and the Knobstone of the Lower Carboniferous Periods. The counties comprised in this area are Putnam, Monroe, Lawrence, Orange, Harrison and Crawford. While much of the area of each of these counties is encroached upon by

* See p. 285.

either the Knobstone or the Mansfield Sandstone, the greater portion of each is covered by one or more of the limestones known as the Harrodsburg, Bedford Oölitic, Mitchell and Huron.

PUTNAM COUNTY.

This county lies about 40 miles west of Indianapolis. It is bounded on the north by Montgomery, on the east by Hendricks and Morgan, on the south by Owen and Clay and on the west by Clay and Parke counties. It is in the form of a rectangle, 27 miles long by 18 wide, with a small additional area near the southeastern corner, its area being 500 square miles.

The rocks forming the surface of the county are the Knobstone, in the northeastern fourth and along the eastern edge; the Harrodsburg limestone, occupying a narrow, irregular strip just to the west of the Knobstone; the Bedford Oölitic limestone, forming a bordering strip west of the Harrodsburg, in the southern half of the county; the Mitchell limestone, covering the greater part of the central third; the Huron limestones and sandstones, along the streams in the southwestern corner; the Mansfield sandstone, over a strip from three to six miles wide along the western border, and the Coal Measures proper, on a few of the higher ridges and hills in the southwestern corner. Every Epoch of the Lower Carboniferous, with the exception of the Goniatite limestone, is thus represented in the county, and, in addition, both epochs of the Carboniferous Era.

In the northern part of the county the drift acquires a thickness ranging from 30 to 60 feet. To the south it becomes thinner, the topography more rugged and outcrops more abundant. The surface in the northern and eastern portions is slightly undulating. In the central, southern and western parts hills arise, and that portion along the streams rises, in places, to abrupt bluffs. The soil, for the most part, is very fertile, and produces large crops of cereals. Corn, wheat and hay are the main products. The limestone area of the central and northern portions is a noted blue grass region, and is famous throughout the country for its production of fine export cattle.

Raccoon Creek drains the northwestern corner, passing into Parke County at Portland Mills. The northeastern, central and

southwestern portions are drained by Walnut Creek and its numerous tributaries, the main stream flowing diagonally across the county in a northeast-southwest direction, and passing into Clay near the southwestern corner. Mill and Deer creeks and their branches drain the southern and southeastern areas.

The transportation facilities of the county are good. The C., I. & L. (Monon) crosses from north to south near the center. The St. Louis Division of the Big Four and the Vandalia both cross from east to west, also near the center, while the Springfield Division of the C., H. & D. runs east and west, close to the northern border.

The available clay deposits of commercial value are few in Putnam County. Such clays do not occur in abundance in a limestone region. Drift clays occur in the northern half, but are usually more or less mixed with lime pebbles and other impurities. One of the best deposits of surface yellow loess clays occurs close to the Big Four Railway just west of Okalla. Three small plants are using the drift clays for making brick, two being located at Greencastle and one at Roachdale. In addition to these, drain tile are being made from a mixture of yellow clay and black, mucky soil near the Owen-Putnam line, about a mile and a half south of Cloverdale.

The Knobstone rocks which outcrop along the streams in the northern and eastern portions of the county are in general too siliceous for use. In several places along Walnut Creek the Knob sandstones are quarried for abutments and foundations. At one of these quarries east of Carpentersville, in the southwest quarter of section 29 (16 N., 3 W.), about ten feet of sandy Knobstone shale occurs above the sandstone forming the face of the quarry. The same character of shale occurs on the Starr land in the northwest quarter of section 6 (15 N., 3 W.), and along Walnut Creek to the southeast. Some of these deposits could probably be made into pressed front or vitrified brick, but their distance from a railway will probably preclude their being so used.

A number of deposits of under-clay of fair workable quality occur in the southwestern portion of the county. In the hills about Reelsville coal I, 18 to 30 inches thick, overlies a soft blue gray under-clay, three to four feet thick. At the Baumunk mine,

in the northeast of section 32 (13 N., 5 W.), the under-clay is three feet four inches thick beneath 28 inches of coal. At the Smith mine, in the northeast of 28, coal III is overlain with three feet of shales and has beneath it two feet of under-clay and a bed of shale whose thickness is not known.

On the William Wright place, in the southeast quarter of section 11 (14 N., 5 W.), coal I, 18 to 26 inches thick, has beneath it 18 inches of workable under-clay. Northwest of Cloverdale, in sections 27 and 34 (13 N., 4 W.), coal III occurs in the hills and overlies a bed of under-clay two to three feet in thickness. A deposit of superior potters' clay also occurs near the schoolhouse in the northwest quarter of section 17 (12 N., 4 W.), which will be found suitable for stoneware or terra cotta.

On the land of M. M. Chittenden, southwest quarter section 32 (13 N., 4 W.), four and a half miles west of Cloverdale, a stratum of potters' clay outcrops from beneath a low bluff. It is probably the under-clay of coal I, and at the point of exposure is three or more feet thick. It occurs over an area of 40 or more acres on the Chittenden farm. Samples sent in to this office show it to be a soft, fine-grained, light gray clay, very plastic when wet and seemingly suitable for stoneware, terra cotta and all kinds of hollow vitrified wares.

At the P. T. Brown bank, in the southwest of section 4 (12 N., 5 W.), the coal is 20 or 21 inches thick, a semi-block, with a good shale roof, and what is claimed to be a fine grade of under-clay, three feet thick, beneath. Most of these deposits are too far distant from railway facilities to be ever put to any use.

MONROE COUNTY.

Monroe County lies southwest of the center of the State, about 60 miles distant from Indianapolis. It is bounded on the north by Owen and Morgan, on the east by Brown and Jackson, on the south by Lawrence and on the west by Green and Owen counties. In shape it closely resembles Putnam, being rectangular in outline, 24 miles in length by 17 miles in width, and with an extension on its southeastern corner, its area being 420 square miles.

The rocks of the Knobstone Epoch occur in the northwestern corner and over a strip four to six miles wide along the eastern

border. West of these, and covering the remainder of the eastern half of the county, is the geode bearing, Harrodsburg limestone, with its characteristic red clay cover. Bordering this on the west, and extending north and south the full length of the county, is a narrow, tortuous strip of Bedford oölitic limestone. Along this strip large quarries of this famous building stone have been recently opened, which are now yielding the finest building limestone produced in the United States. The Mitchell limestone borders the Oölitic on the west, and covers a strip two to six miles wide, west and northwest of Bloomington. The surface of the southwestern portion is occupied by rocks of the Huron Age.

On account of this representation of so many members of the Lower Carboniferous period, each varying in degree of its susceptibility to erosion, the surface of the county is very diversified, the eastern tier of townships being very hilly, almost mountainous; the southern part gently rolling; the western portion rather level; the northern somewhat hilly, while the central is undulating. Lying as it does south of the drift area of the State, the inequalities of the surface have never been leveled or filled by glacial action, and are therefore the more noticeable. The soil of the valley and more level portions is quite fertile, but that of the uplands, especially in the eastern and northern townships, is thin and poor.

The West Fork of White River forms the boundary at the northwestern corner of the county and receives therefrom as its largest tributary, Bean Blossom Creek, which, with its branches, drains the northern half. Salt Creek enters on the eastern boundary near its center and, flowing southwest to near the center of the southern boundary, drains the southeastern fourth. Clear Creek, rising near the center, flows south, then southeast, into Salt Creek, and drains the greater part of the southwestern portion.

Up to the present the transportation facilities of the county have been poor, the only railway entering its bounds being the C., I. & L. (Monon), which crosses it in a northwest-southeasterly direction. Numerous spurs of this road have been constructed to the leading quarries, and so have made available portions of the county not touched by the main line. The Indianapolis Southern Division of the Illinois Central, now in course of construction, will cross the county from northeast to southwest near its center,

while the Indianapolis & Martinsville Rapid Transit Co. will soon extend its electric line from Martinsville to Bloomington, thus putting that city in direct communication with Indianapolis by both steam and electric power.

The deposits of available commercial clays in Monroe County have, up to the present, been few. With the completion of the Indianapolis Southern a number of Knobstone shale deposits in the northeastern part will become easy of access. One of the best of these is that on the land of James McLary, close to the Monroe-Brown line, in the northeast quarter of section 2 (9 N., 1 E.). The grade of the railway here passes through a cut made in the slope of a hill, the cut being several hundred feet in length and 30 feet deep. The shale, exposed to the full depth of the cut, is a soft, gray, unctuous material, wholly free from grit, and resembling closely in appearance the better grade of the Coal Measure shales, 40 miles to the west. In September, 1904, less than a year after being exposed, the sides of the cut had everywhere weathered into small, quadrangular pieces, which indicates that the shale can be easily ground and the resulting clay worked into any desired shape. An analysis of samples of this shale showed its constituents to be as follow:

Analysis of Knobstone Shale from Land of Jas. McLary.

Silica (SiO_2)	58.22
Titanium oxide (TiO_2).....	1.15
Alumina (Al_2O_3)	19.63
Water combined	6.61
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Clay base and sand.....	85.61
Ferric oxide (Fe_2O_3).....	5.88
Calcium oxide (CaO).....	1.95
Magnesia (MgO)	2.10
Soda (Na_2O)68
Potash (K_2O)	3.93
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Fluxes	14.54
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Total	100.15

The analysis shows the shale to be suitable for the clay ingredient of Portland cement. It can also be burned into paving brick, sewer pipe and hollow vitrified products of many kinds. Ordinary or dry pressed front brick can also be made from it.

In color it will probably burn to a dark cherry red. With an abundance of Oölitic and Mitchell limestone, suitable in every way as the carbonate of lime ingredient of Portland cement, in the immediate vicinity of Bloomington, a large factory for the making of such cement should be there erected and the clay secured from the McLary deposit. The haulage distance would be less than that for the shale used at the Lehigh factory at Mitchell. Other tracts underlain by similar shale doubtless occur along the Indianapolis Southern in northeastern Monroe, but time did not permit their investigation.

Nearer Bloomington, toward their western horizon, the Knob shales are more siliceous, and suitable only for making ordinary pressed front or vitrified brick. Samples from one of these outcrops, located two miles northeast of Bloomington, in the northeast quarter of section 27 (9 N., 1 W.), were analyzed by Dr. Noyes and their composition found to be:

Analysis of Knobstone Shale from a point two miles northeast of Bloomington.

Silica (SiO_2)	74.43
Alumina (Al_2O_3)	6.88
Water combined	2.24
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Clay base and sand.....	83.55
Ferric oxide (Fe_2O_3).....	6.52
Ferrous oxide (FeO).....	2.10
Lime (CaO)	1.32
Magnesia (MgO)	1.36
Potash (K_2O)	2.40
Soda (Na_2O)	1.86
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Fluxes	15.56
Carbon dioxide (CO_2).....	.75
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Total	99.86

The high percentage of silica in this shale precludes its use for Portland cement making. Sample pressed front brick of good quality have been made from the exposure.

The surface clays of Monroe are, most of them, residual clays, *i. e.*, have been formed where they now lie by the partial decomposition and weathering of the underlying surface rocks. They range in thickness from one up to 12 or 15 feet. That found above the Harrodsburg and Oölitic limestones is usually a dark red

in color, while that above the Mitchell limestone is grayish to brownish yellow. Analyses of three of these clays—No. 1, a red clay from an excavation for the students' building at Indiana University campus; No. 2, a similar clay from above the Oölitic limestone of the National Stone Company's quarry, southwest quarter of section 33 (8 N., 1 W.), four miles south of Bloomington, and No. 3, from above the Mitchell limestone, nine miles south of Bloomington—were made; the first by L. M. Kibler, a student in the chemical department of Indiana University, and Nos. 2 and 3 by Dr. Noyes, and their chemical composition found to be as follows:

Analyses of Surface Clays from Monroe County.

	No. 1.	No. 2.	No. 3.
Silica (SiO_2)	67.15	72.56	79.99
Titanium oxide (TiO_2).....	....	.31	....
Alumina (Al_2O_3)	13.96	10.44	8.66
Water combined	3.25	4.54	3.55
Clay base and sand.....	84.36	87.85	92.20
Ferric oxide (Fe_2O_3).....	6.84	7.45	....
Ferrous oxide (FeO}).....	....	.43	3.31
Lime (CaO)	1.23	.82	.57
Magnesia (MgO}) .....	.54	1.09	.77
Potash (K_2O)	1.18	2.05	1.93
Soda (Na_2O) ..	3.33	.73	.83
Fluxes	13.12	12.57	7.41
Carbon dioxide (CO_2).....	....	....	.33
Moisture	3.00	....	....
Total	100.48	100.42	99.94

All of these clays are too high in silica for Portland cement making and contain too high a percentage of fluxes in proportion to their alumina for vitrified products. They can be made into ordinary brick and drain tile. The deposit from which No. 2 was obtained is on a spur of the Monon Railway, and the clay runs four to five feet in thickness.

Samples of surface clay from the lands of O. M. Fulwider: No. 1 from a tract nine miles southwest of Bloomington, north-east quarter of section 11 (7 N., 2 W.), and No. 2 from another tract five and a half miles south of Bloomington, southwest quarter section 32 (8 N., 1 W.), have been partially analyzed by Dr. Lyons, and the following constituents found to be present:

Partial Analyses of Surface Clays from Lands of O. M. Fulwider.

	No. 1.	No. 2.
Silica (SiO_2)	69.65	59.23
Alumina (Al_2O_3)	14.92	18.45
Ferric oxide (Fe_2O_3)	5.59	8.77
Titanium oxide (TiO_2) .....	.77	.78
Loss on ignition	4.70	8.50

The analyses show No. 1 clay to be too high in silica and No. 2 too high in iron oxide to serve as the clay ingredient of Portland cement. Similar clays have been tried at the U. S. Portland Cement Plant at Bedford, and have failed to give satisfaction. Their composition is not sufficiently uniform and there is trouble in drying and grinding them. The limestone beneath these clays on the Fulwider land ran respectively 97.84 and 98.88 per cent. carbonate of lime, which is above the average of the Oölitic stone. They will be found in every way suitable as the carbonate of lime ingredient of Portland cement, but the clay would have to be obtained elsewhere.

The only clay industry at present operating in Monroe County is that of the Dolan Brick and Tile Co., located at Dolan, six miles north of Bloomington. The raw material used is a "soft soapstone underlain with blue sedimentary clay." The output is small, being reported as 75,000 ordinary brick, 2,500 rods of tile and 5,000 hollow block in 1904; the total value of the output being \$1,550.

LAWRENCE COUNTY.

Lawrence County is situated in the southwestern part of the State, 75 miles southwest of Indianapolis. It lies south of Monroe, west of Jackson and Washington, north of Orange and east of Martin and Greene counties. In outline it is nearly square, being 22 miles in width from east to west and 21 miles in length; its area being 454 square miles.

The rocks forming the surface of the county represent six geological epochs. The Knobstone covers the northern half of the northeastern fourth and a narrow strip along the eastern border. The Harrodsburg limestone forms the greater part of the eastern half, and where eroded through by the streams, has exposed the underlying Knobstone in a number of the valleys. The famous Bedford Oölitic limestone covers a narrow irregular strip just to

the west of the Harrodsburg. The Mitchell limestone occurs over the surface of a strip three to nine miles in width extending from northwest to southeast, just west of the center, the wider portion being in the area south of White River. The Huron group covers large areas in the northwestern and southwestern portions, while the Mansfield sandstone forms the surface of some of the higher elevations in the extreme southwestern corner.

On account of the presence of so many rock formations, the surface of the county is exceedingly diversified. "The eastern and northeastern parts are undulating or gently rolling plateaus drained by deep narrow valleys, the central region north of White River is hilly, and the western and southwestern is rough and broken. Each of these divisions is covered with a soil almost wholly formed from the decomposition of underlying rocks; we consequently find the soil in the first tenacious clay and sand; of the second, a calcareous clay, and of the third principally siliceous material, with an intermixture from both of the others. In that part of the county underlain by the Oölitic and the Mitchell limestones, comprising a broad belt about 12 miles wide, passing centrally from northwest to southeast, 'sink holes' are so numerous as to form a striking feature in the configuration of the surface."

The East Fork of White River which, with its tributaries drains the entire county, crosses the county from east to west in a very meandering course a little south of the center. It is a broad clear stream, as large as the Wabash at Lafayette, and flowing with a rapid strong current. From the north it receives Indian, Salt, Leatherwood and Guthrie creeks, while from the south enter Sugar, Fishing and Beaver creeks.

The transportation facilities of the county are excellent. The C., I. & L. (Monon) bisects it from north to south, while its Bedford and Bloomfield Branch runs northwest from the former town. The Southern Indiana enters the county on its western border south of the center and, running northeasterly, leaves near the northeastern corner. The B. & O. S. W. crosses the southern third from east to west and sends a spur from near the southeastern corner to Bedford. All these roads are connected by a belt line at Bedford, which permeates the famous Oölitic stone district northwest of the town.

Lawrence County possesses a number of excellent clay deposits. The Knobstone shales in the northeastern part run from one to 250 feet in thickness. Some of the main exposures are along the line of the S. I. Railway in the vicinity of Heltonville. In the bluffs of Leatherwood Creek, one and a half miles southwest of Heltonville, the shale is exposed 30 or more feet in thickness within less than a quarter of a mile of the railway. Fine exposures occur just south of Heltonville, and also a mile west of Zelma. While the shale in most of these exposures will probably run too high in silica for Portland cement or hollow vitrified products, there is little doubt but that it can be made into ordinary, dry pressed or vitrified brick of good quality.

Analyses of samples from two of these Knobstone shales, from the land of W. H. Gregory, southwest of Heltonville, were made for Mr. H. H. Walls, of Bedford, and their composition found to be as follows:

Analyses of Knobstone Shales from near Heltonville.

	No. 1.	No. 2.
Silica (SiO_2).....	74.07	68.90
Alumina (Al_2O_3)	13.14	17.20
Water combined	3.90	3.97
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Clay base and sand.....	91.11	90.07
Ferric oxide (Fe_2O_3).....	5.75	5.05
Ferrous oxide (FeO).....	.95	1.05
Lime (CaO)13
Magnesia (MgO)	1.95
Potash (K_2O)60	.85
Soda (Na_2O)	1.20	1.00
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Fluxes	8.63	9.90
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Total	99.74	99.97

The analysis shows No. 1 too high in silica for any purpose but brick-making. No. 2 can be used for Portland cement and also for clay wares. Either of the two will make a high grade of pressed front or vitrified street brick. The stripping above the shale is, however, quite heavy, running eight to 15 feet in thickness.

Partial analyses of a number of the residual surface clays overlying the Bedford limestone in Lawrence County have been made

by F. E. Walker, chemist of the U. S. Cement Co., of Bedford. The results of eight of these have been kindly furnished me by Mr. Walker, as follows:

Partial Analyses of Residual Surface Clays from Lawrence County.

	No. 1.	No. 2.	No. 3.	No. 4.	No. 6A.	No. 6B.	A.	B.
Silica (SiO ₂)	72.40	67.07	71.97	68.70	78.96	66.62	63.77	78.93
Alumina (Al ₂ O ₃)	20.20	17.14	20.17	16.55	15.46	16.24	17.62	13.93
Ferrio oxide (Fe ₂ O ₃) {		5.96	comb	5.82	comb	7.14	7.92	
Lime (CaO)	3.30	2.70	2.40	3.07	.38	.38	2.80	Trace
Magnesia (MgO)	1.05	.91	.50	.31	.22	.57	1.09	Trace
Loss		7.50		6.78		7.56	7.24	6.72
	101.28			100.92	45.02	98.51		99.58

All of these clays contain flint pebbles and considerable quantity of grit.

The most noted clay in Lawrence County is the kaolin or Indianaite, the main deposits of which occur in sections 21 and 22 (4 N., 11 W.), about four miles northeast of Huron, a station on the B. & O. S. W. near the southwestern corner of the county. This kaolin is the purest form of clay found in Indiana, but is almost wholly lacking in plasticity. The principal deposits belong to Dr. J. Gardner, of Bedford.

These deposits were first brought to public notice by State Geologist E. T. Cox in the report of this Department for 1874. Locally the outcropping kaolin had been previously known as mineral tallow, and the locality as Anderson's "taller bank." Some workmen in the summer of 1874, while digging out the underlying iron ore for the blast furnace at Shoals, laid bare the full thickness of the stratum of kaolin, and the attention of Mr. Cox was called to it. Dr. Gardner became interested and purchased the land, and extensive tests and analyses were made which proved the great purity and value of the clay. For some years it was mined and sold to Tempest, Brockman & Co., of Cincinnati, who used it as one of the principal constituents in the making of a white porcelain ware of excellent grade. Later the land was sold to the Pennsylvania Salt Company, of Philadelphia. This company for ten years mined annually an average of 2,000 tons of the kaolin. This was shipped to Philadelphia where each ton was mixed with two tons of dilute sulphuric acid, and formed three tons of "alum cake." This brings from \$25

to \$35 a ton, and is sold mainly to paper manufacturers as a sizing for the better grades of wall and writing paper. The deposits are four miles from the B. & O. S. W. Railway, necessitating the hauling of the clay that distance over a rough road. The Salt Company finally began to make alum salt from a deposit of cryolite which could be shipped to their works near Philadelphia in sailing vessels at a much reduced cost, and gradually abandoned the use of the kaolin. The land was then sold back to the former owner, Dr. Gardner, and the deposits have not been worked since 1891.

A partial section of the hill in which the best exposures of the kaolin occur shows as follows:

Section of Hill Northeast of Huron, Containing Large Deposits of Kaolin.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil and clay.....	3	0
2. Mansfield sandstone	100	0
3. Kaolin—replacing coal 1.....	6	0
4. Iron ore—limonite	2	0
5. Shale, marly and siliceous.....	5	0
6. Huron sandstone	50	0
7. Huron limestone	17	0

In the working of the deposits in the past, three slope shafts, each several hundred yards in length, have been put back into the hills in which the kaolin is found. The stratum of kaolin has a maximum thickness of 11 feet, and a minimum of four, the average being five and a half to six feet in the area worked over. It lies in a horizontal stratum like a vein of coal, and is mined in much the same manner, though with much less blasting. The overlying sandstone varies much in character. In some places it is a true conglomerate, containing many small quartzose and other pebbles, cemented together with a material which, according to Dr. Noyes, contains considerable amounts of alumina. In others it is the fine grained, pinkish brown, shelly sandstone, already noted, as forming the roof over similar deposits at Dover Hill, Martin County. In places there are narrow cracks or crevices, extending a foot or more into the roof, which are filled with the kaolin. Again, small irregular masses of the kaolin are found, as a part of the conglomerate, at a height of six or eight feet above the main stratum.

In many places at the upper portion of the bed of kaolin, and lying immediately in contact with the roof, are masses of the semi-transparent, light green mineral known as *allophane*, in which the percentage of alumina and water are the same, and double that of the silica, as follows:

Water	40 per cent.
Alumina	40 per cent.
Silica	20 per cent.

On exposure to the air, the water of crystallization shortly passes off and the mineral effloresces into a white powder, made up of particles resembling, in a general way, those of coarse corn meal.

The upper half of the kaolin stratum is mainly composed of a massive, snow-white clay, which has a smooth, unctuous feel. Associated with this, especially near its top, are occasional concretionary or nodular masses, often a foot or more in diameter which, when broken, show a light blue, lamellar center. Both of these forms disintegrate, on exposure to the air, into a rather coarse grained white powder.

The lower half of the stratum of kaolin in the Huron mines varies in color from a pale buff to a rich deep brown. This is due to its being stained with the oxides of iron and possibly those of manganese and cobalt. Such a clay, while unfit for porcelain ware can, however, be used in the making of certain grades of "alum salt," and for this purpose much of it has been utilized in the past.

An analysis of an average sample of the massive white variety made by Dr. Noyes* shows the following result:

Analysis of Kaolin from Land of Dr. J. Gardner, near Huron, Lawrence County.

Silica (SiO_2)	44.75
Alumina (Al_2O_3)	38.69
Water combined	15.17
Clay base	98.61

*The mineral contains no titanium and less than one per cent. of it is insoluble, on treatment with sulphuric acid and sodium carbonate. It is a very nearly pure kaolin, for which the theoretical composition would be, from the formula, $\text{Al}_2\text{Si}_2\text{O}_7 + 2\text{H}_2\text{O}$, the composition being as follows:

Silica	46.51 per cent.
Alumina	39.53 "
Water	13.96 "

W. A. Noyes.

Ferric oxide (Fe_2O_3).....	.95
Lime (CaO}) .....	.37
Magnesia (MgO}) .....	.30
Potash (K_2O}) .....	.12
Soda (Na_2O}) .....	.23
<hr/>	
Fluxes	1.97
<hr/>	
Total	100.58

The sum total of the impurities is thus seen to be less than two per cent. The quantity of iron is so small as to have no effect upon the color of the burned ware, which is, if anything, whiter than the clay itself.

Like many similar kaolins, this is practically non-plastic; but by grinding very fine and then kneading, it can be made to assume a certain degree of plasticity. According to Dr. Gardner, it is somewhat remarkable for the weakness of affinity existing between its silica and alumina. It will give up its alumina to acids or its silica to alkalies with great freedom until after it has been heated to redness and the chemically combined water is driven off, when it acts the same as other clays. On account of this weakness of affinity it is well suited for the making of such chemical compounds as the alum salts.

The refractory properties of this clay are of the highest, as its composition shows. Mixed with a small percentage of a more plastic material, as one of the purer under-clays of the Coal Measures, it can be used in the making of the finer grades of retorts, glass pots, glass tanks, saggars, etc. Ground fine with a bond clay and pressed dry, it will make the highest grade of fire brick.

The best flint clays of Ohio and Kentucky from which the high grade refractory products of those states are made, are, like the Lawrence County kaolin, wholly non-plastic, and have to be mixed with a plastic under-clay before they can be burned into fire brick and similar products. Analyses of three of the best known flint clays of Ohio and Kentucky are here given side by side with that of the Indiana kaolin in order to show their close similarity in composition:

Analyses of Lawrence County Kaolin and Ohio and Kentucky Flint Clays.

	<i>I.</i>	<i>II.</i>	<i>III.</i>	<i>IV.</i>
Silica (SiO_2)	44.75	46.75	44.60	43.19
Alumina (Al_2O_3)	38.69	38.17	40.05	41.60
Water (combined)	15.17	14.03	14.23	13.48
Clay base	98.61	98.95	98.72	98.27
Ferric oxide (Fe_2O_3).....	.95	.29	.80	....
Lime (CaO}) .....	.37	.57	.27	.15
Magnesia (MgO}) .....	.30	.12	trace	.06
Potash (K_2O}) .....	.12	.07	trace	.95
Soda (Na_2O}) .....	.23	trace	trace	trace
Fluxing impurities ..	1.97	1.05	1.07	1.70
Totals	100.58	100.00	99.99	99.97

Of these, No. I is the Lawrence County kaolin; No. II, a flint clay from Carter County, Kentucky; No. III, the Gaylord flint clay from Scioto County, Ohio, and No. IV, the Stone City flint clay from Stone City, Kentucky. Nos. II and III are used by the Portsmouth Fire Brick Co., of Portsmouth, Ohio, as the main body mixture for their noted refractory wares.

Mr. H. A. Treudley, of the B. & O. S. W., has recently written me that "A manufacturer of pottery from East Liverpool, Ohio, who investigated the Huron deposits, stated that if the kaolin could be mined, ground, washed and delivered in East Liverpool at \$12.00 per ton, the 43 different firms engaged in the manufacture of pottery at that place could use all that could be gotten out, as it would, in many instances, supplant the clays that are being shipped from England. He thinks that if a company could be organized to work this clay on this basis, it could be made a very profitable industry."

Recent experiments have proven the kaolin suitable for making a filler for furniture and buggies; also for cosmetics and ultramarine. Ground fine, with a little sugar and flavoring, it will make a dentifrice that, for cleansing and polishing the teeth, can not be surpassed.

Besides the deposits which have been worked on the Gardner lands in the southeast quarter of section 21, thick beds of the kaolin occur on the northeast quarter of the same section; on the northwest of section 22 and on the northeast of 33; all in township 4 north, 2 west.

However, thousands of tons of this purest of clays are visible in the mines which have been already opened. The stratum thickens as progress is made farther back into the hills. The deposit is not a local one, covering a few rods or acres, but square miles, as evinced by outcrops which are known. There is enough in sight in the mines at this one deposit to last an average factory a hundred years, and not one one-thousandth of it has been exposed to view. There it lies, a great mineral resource of untold value, unworked, unutilized, awaiting only the coming of energy and capital to make it up into many kinds of products which are now brought into our State from distant lands.

ORANGE COUNTY.

Orange County occupies a place in the second tier of counties north of the Ohio, about 85 miles southwest of Indianapolis. Lawrence County forms its northern and Crawford its southern boundary. Washington and Crawford bound it on the east and Martin and Dubois on the west. The county is square in outline, 20 miles in length by 20 in breadth, with an area of 400 square miles.

The Mitchell limestone forms the surface of the eastern two-thirds of the northern half. The Huron limestones and sandstones cover the southern third and part of the northwestern fourth, while the Mansfield sandstone occurs on the higher ridges in the southwestern and northwestern portions.

The northeastern part of the county, embraced in the Mitchell limestone area, is comparatively level, but the topography is varied by the numerous sink holes and basins, characteristic of that formation. The southern, central and especially the western parts of the county are very rugged and broken. High and steep ridges, with narrow winding valleys, are the prevailing surface features. Mount Arie, near West Baden, and Burtin Hill, southwest of French Lick, are two of the highest points in this region. Two streams, Lost River and Patoka River, with their tributaries, drain the county. Their general course is from east to west, but very meandering, the former across the northern and the latter across the southern thirds.

But one railway, the C., I. & L. (Monon), enters the county.

The main line of this road cuts across the northeastern corner and from its principal station, Orleans, diverges a branch line to Paoli, the county seat, and the famous West Baden and French Lick springs in the central and western portions.

The available commercial clay deposits of the county are few in number. Lying as it does between the Knobstone and Coal Measure areas, the shales of those formations are wholly lacking. A number of outcrops of under-clay of coal I occur, but they are all distant from railways.

At Braxton's whetstone quarry, in the southeast quarter of section 31 (2 N., 2 W.), the following connected section was obtained by Dr. E. M. Kindle:

Section at Braxton's Quarry.

	<i>Feet.</i>	<i>Inches.</i>
1. Covered	20	0
2. Bluish gray sandy shale, with sandstone.....	3	0
3. Coal Ia	2	8
4. Sandy shale	3	0
5. Covered	20	0
6. Soft gray clay shale.....	6	0
7. Whetstone strata	14	0
8. Shale	7	0
9. Whetstone	2	6
10. Coal I	1	2
11. Under-clay	8	0

Of these, Nos. 6, 8 and 11 could be burned into a number of different kinds of clay products.

At Nation's coal bank, near the northeast corner of the county, northwest quarter of section 29 (3 N., 2 W.), coal I, 20 inches thick, overlies two and a half feet of a good quality of light gray, unctuous under-clay. The roof above the coal is a drab colored clay shale, six feet in thickness, also of fair workable quality. About three-quarters of a mile northeast, at the William Tulliver bank, southeast quarter of section 20 (3 N., 2 W.), the roof is a gray sandy shale, three feet thick, while the under-clay runs about as at Nation's.

At the I. V. Nelson bank, south of Lost River, southwest quarter of section 32 (2 N., 2 W.), coal Ia, 27 inches thick, is underlain with 18 inches of bone coal, the latter overlying a fair quality of under-clay eight to 10 feet in thickness. Above the worked coal is a thin layer of blue gray sandy shale.

Messrs. Elrod & McIntire, in their report on the Geology of Orange County,* make the following remarks regarding the clays of the county:

"A fine lacustral clay abounds in the northeastern part of the county, which has been manufactured into stoneware of a very good quality, at Lancaster, on the L., N. A. & C. (Monon) Railway. It could be worked to good advantage into roofing or drain tiles. We find kaolin in the county, but as yet not in quantities to render it of any commercial value. Samples of good Indianaite have been picked up on the land of Mr. O. Burnett, section 20 (3 N., 1 W.). A three foot stratum of a very fine yellow ochre is exposed on the land of Mr. Freeman, section 7 (1 N., 2 W.)."

The late Hon. Amos Stout, of Paoli, at one time sent in to this office small pieces of kaolin, of which he wrote: "I am informed that there is quite a vein of it extending entirely through a very large hill about three miles southeast of French Lick, in sections 13 and 14 (1 N., 2 W.). The party who brought in the samples states that it occurs in unlimited quantities in that locality."

No clay working industry of any kind is at present located in Orange County.

HARRISON AND CRAWFORD COUNTIES.

These two counties lie side by side, on the north bank of the Ohio River, in the southern portion of the State. Their combined area is 774 square miles. They lie south of Washington and Orange, west of Floyd and east of Dubois and Perry counties, and are separated by Blue River.

The Mitchell limestone covers the greater part of Harrison, while the Huron group and the Mansfield sandstone form most of the surface of Crawford, the latter being confined to the western third. A few of the higher hills and ridges near Taswell and Eckerty are covered with rocks of the Coal Measure Epoch.

The surface of Harrison County is considerably diversified, the valleys along the rivers and streams being chiefly level or bottom lands, while the hills which extend along the Ohio River often rise to the height of 200 or 300 feet, presenting picturesque and

* Geol. Surv. of Ind., 1875, p. 234.

beautiful scenery. These knobs, together with the higher ridges of the county generally, are among the best lands for fruit raising in the State.

The surface of Crawford County is more broken and hilly; a long chain of hills from 250 to 480 feet in elevation, present themselves above the Ohio and Blue rivers. From the center, extending toward the knob range south and east, there is a considerable stretch of comparatively level land. The soil on the river and creek bottoms is quite fertile. That upon the uplands and hilly portions of the county is well adapted to fruit, and increased attention is being given to horticulture.

Both counties drain directly into the Ohio, mainly through Blue River and its tributaries. Indian and Buck creeks in Harrison, and Little Blue in Crawford, are other streams flowing southwest or south into the Ohio. A small portion of northwestern Crawford drains into the Patoka.

The principal railway in the two counties is the St. Louis Division of the Southern, which crosses the northern third from east to west. The L., N. A. & C., a short spur of this line, but operated independently, runs between Corydon Junction and Corydon, the county seat of Harrison. The Ohio River furnishes a good outlet for the southern portion of their areas.

The Knobstone shales which outcrop in eastern Harrison in a narrow strip along the Ohio River front, weather in many places into a fine plastic clay, which can be made into vitrified, pressed front or ordinary brick. The river would furnish excellent transportation facilities for any factory which might be erected for their utilization.

Kaolin occurs in connection with the glass sand deposits in the eastern part of the county, one to three miles back from the river. The best known deposits are in the northwest quarter of section 35 (4 S., 5 E.), two miles east of Elizabeth, and in the south half of section 15 (5 S., 5 E.); two miles northeast of Buena Vista. A lack of time prevented me from visiting these deposits, and so I quote as follows from Collett's report on the Geology of Harrison County.*

"In working the sand banks, pockets and beds of white kaolin were discovered. The sand miners were not searching for porce-

* Geol. Surv. of Ind., 1878, p. 416.

lain clay, and disregarded the 'white putty,' as they termed it, from its plastic nature. Small fragments were seen at the banks east of Elizabeth, and at the Peters farm near Eversole Cliff. These were pure white and almost entirely free from iron. Just east of the last point an immense stratum of kaolin was noticed, more than 50 acres in extent; the bed is nearly continuous, and from three to five feet thick. At the exposed point it varies in color from ash gray to pale green, pink, red and dark brown, the first colors predominating. A sample of the green variety, analyzed by Dr. Levette, gave the following result:

Analysis of Kaolin from Harrison County.

Water (H ₂ O)	9.00
Silica (SiO ₂)	58.70
Alumina (Al ₂ O ₃)	28.00
Ferric oxide (Fe ₂ O ₃)	5.50
Magnesia (MgO) .....	.80
Lime (CaO) .....	....

This extensive bed will, it is believed, prove of value for making yellow ware, tiles, water tubes, fire brick, ornamental terra cotta ware and, perhaps of more importance, as an addition in manipulating artificial cement."

The only clays of any importance in Crawford County are the under-clays and shales accompanying coals I and II in the western third. Coal II is confined to the tops of the dividing ridges between Taswell and English and between Eckerty and Birdseye, along which the Southern Railway runs. A section at the railway tunnel, two miles east of Taswell (southeast quarter of section 21 (2 S., 1 W.), shows the presence of the following strata:

Section at Tunnel East of Taswell.

	<i>Feet.</i>	<i>Inches.</i>
1. Surface clay	6	0
2. Blue clay shale	5	0
3. Coal II?	1	9
4. Blue clay shale	8	0
5. Coal Ia?	1	6
6. Blue clay and shale.....	5	0
7. Massive sandstone	6	0
8. Blue clay shale	13	0

The greater part of Nos. 2, 4, 6 and 8 could be used for clay products.

Beds of fair under-clays are found beneath coal II at Smith's bank, northwest quarter of 31 (2 S., 1 W.), a mile and a half south of Taswell and at the mine one half mile southeast of Wickliffe, north half of section 9 (2 S., 2 W.).

At the Gresham place, two miles southeast of Eckerty, considerable coal was formerly dug for blacksmithing. The coal is in two layers, 14 and eight inches in thickness, with a six foot vein of soft blue under-clay between them.

In a ravine on the Adkins land, east half of section 16 (2 S., 2 W.), is an exposure of coal Ia, 14 inches thick, with three feet four inches of a gray sandy under-clay beneath. The latter appears well suited for refractory products.

Just north of the water tank at Eckerty, is an exposure of a two and a half inch vein of coal which overlies four feet of gray sandy under-clay, which might be worked for several kinds of clay wares.

There is not a clay factory of any kind at present operating in Harrison or Crawford counties, all brick and other articles of clay being imported.

III. COUNTIES OF THE DEVONIAN AREA.

As already noted, the rocks of the Devonian area in Indiana offer little or nothing in the way of raw material to prospective clay manufacturers. Of the counties mentioned* as having part or all of their surface in that area, Jackson has been already described, since most of its area is covered by Knobstone; while Jasper belongs more properly to the deep drift covered area of northern Indiana. In a few of the remaining counties are deposits of the Knobstone shale, but otherwise, ordinary surface drift or alluvial clays form the only clay working material. For that reason, but brief mention of each county will be made.

CLARK COUNTY.

This county lies on the Ohio River, east of Floyd and Washington, and south of Scott and Jefferson counties. The rocks forming the surface, named in order from east to west, are the Lorraine and Richmond Divisions of the Lower Silurian; the Niagara of the Upper Silurian; the Jeffersonville and Sellersburg limestones and New Albany or Genesee shale of the Devonian, and the Knobstone of the Lower Carboniferous Periods.

The Knobstone covers an irregular area two to eight miles in width along the western and especially the northwestern border. The J., M. & I. Division of the Pennsylvania Railway runs close to numerous outcrops of Knobstone shales between Memphis and Henryville, and between the latter point and Underwood the road-bed, for the most of the way, is underlain with such shales. The C., I. & L. (Monon) also crosses the area covered by these shales between St. Joseph and Borden, while the Louisville Division of the B. & O. S. W. touches them at Otisco.

These Knobstone shales are the soft drab to grayish blue, clayey shales, which lie at the base or along the eastern horizon of the Knobstone in this section of the State. They weather readily into a plastic clay which can be used for either ordinary soft mud or dry pressed brick, or for stiff mud vitrified paving brick. The more plastic deposits can also be burned into hollow block, sewer pipe, etc.

* See p. 46.

The Silver Hills, comprising the main chain of "Knobs" in this region, extend in an unbroken line from New Albany to Borden. Some of the best exposures of the shales are just northwest of Memphis, on section 219, Illinois Grant, and along Blue Lick and Cany Fork. A number of Knob shale outcrops occur on the west side of and close to the J., M. & I. Railway, between Memphis and Henryville, which could be utilized for many kinds of clay products. The exposures on the east side of the railway, between the points mentioned are all of the New Albany black shale, and are worthless for clay working purposes. Numerous other outcrops occur in the regions west of Henryville and Memphis, that are more distant from railway facilities.

On section 274, Illinois Grant, three and a half miles northwest of Henryville, there is a 20 foot exposure of the soft grayish blue shale, with six bands of kidney iron ore, three to eight inches in thickness, at intervals of two to four feet.

The only clay working industry in Clark County at present is that of the Jeffersonville Brick Co., located in the environs of the northwestern part of that city. Ordinary stiff mud building brick are made from a deposit of clean, tough alluvial clay, from one of the old terraces or second bottoms of the Ohio. The clay runs buff to gray in hue and contains sufficient iron to give the brick a fine red color. About eight feet are used, after stripping an inch or two of soil. The output in 1904 was one million, which sold at \$5.75 per thousand at the yard.

An alluvial blue clay found in the lowlands near Port Fulton, just above Jeffersonville, was formerly extensively used for stoneware, such as crocks and jugs, and also for drain tile.

SCOTT COUNTY.

This is a small county of very irregular outline, lying north of Clark and west of Jefferson. Its area is 213 square miles. The Jeffersonville limestones outcrop along the streams of the eastern third, but the New Albany black shale forms the greater part of the surface rocks of the county. The southwestern portion is covered by the Knobstone of the Lower Carboniferous, at the base of which lie thick deposits of fine gray clay shales, suitable for clay working purposes.

Between Underwood and a point a mile north of Vienna, on the J., M. & I. Railway, the shales outcrop in various places. Some high knobs occur about one mile southwest of Underwood, the lower portions of which are composed of this shale. The same shale outcrops along Big Creek, from a point two miles west of Austin to where the stream crosses the Jackson county line. Southwest of Vienna the shale is exposed at numerous places on Big Ox Creek and its tributaries. Almost any of these exposures can be used in the making of soft mud or dry pressed building brick or vitrified street brick of high grade.

Three or four factories making ordinary brick and drain tile from surface clays are in operation at Scottsburg, the county seat.* The clay is used to a depth of three feet after stripping six to eight inches of soil.

JENNINGS COUNTY.

This county, comprising 380 square miles, lies north of Scott and Jefferson, and east of Jackson and Bartholomew counties. The east and west sides of the county are nearly parallel, but the north and south borders are very irregular. The surface rocks represent the Niagara Epoch of the Upper Silurian; and the Jeffersonville Limestone and New Albany Black shale of the Devonian Periods. No one of these comprises any clay working material, so that alluvial and drift clays for ordinary brick and drain tile are the only forms found in the county. The following section of a well near Paris Crossing will show the relation of the beds of surface clay:

Section of Well near Paris Crossing.

	<i>Feet.</i>	<i>Inches.</i>
1. Light colored clay, with deeper shades below	10	0
2. Ochre colored clay with flint pebbles, increasing in hardness toward the bottom	19	0
3. Very hard bed clay and gravel (hard pan)	3	0
4. Blue drift clay, very sandy, with organic remains.	10	0

The clay lands of the "flats" which form the water-sheds between all the streams, are of the Champlain period, and contain vegetable material which was borne down from the higher lands and deposited far above the flood tides of the streams of the

* See statistical table at end of paper.

present age. There are deposits of blue clay in the lower parts of these beds, often but two or three feet from the surface, well suited to the manufacture of drain tile.

Two factories at North Vernon* make ordinary brick from an ocherous yellow clay, using from two to three feet after stripping a few inches of soil. The output of both yards in 1904 was 950,000 brick, which brought \$5.00 to \$5.50 per thousand. Drain tile were made near the same town for a number of years previous to 1902, but as most of the wet land of the county has been drained, the enterprise was abandoned.

BARTHOLOMEW COUNTY.

This county, comprising an area of 400 square miles, is situated southeast of Indianapolis about 40 miles. It lies north of Jackson and Jennings, east of Brown, south of Johnson and Shelby and west of Decatur and Jennings counties. The surface rocks of the county, underlying the drift and exposed in many places along the streams, are the Jeffersonville Limestone and New Albany shale of the Devonian and the Knobstone of the Lower Carboniferous Periods. In addition to these, the Niagara limestone is exposed along Clifty Creek, near Hartsville. The Jeffersonville limestone occurs in a strip one to six miles in width along the eastern edge of the county. The New Albany shale covers more than half the entire area occupying a broad strip through the center. The Knobstone covers the greater part of the western third. On account of the broken nature of this region, it is locally known as the "Brown County edge of Bartholomew." Dr. M. N. Elrod has given the following connected section of the rocks of the Knobstone Epoch as represented in the county:†

Section of Knobstone Group or Epoch in Bartholomew County.

	<i>Feet.</i>
1. Sandstone, coarse textured with bands of iron ore and shale partings	95
2. Sandstone, even bedded, light colored quarry stone.....	40
3. Shale and sandstone in thin beds.....	50
4. Shale and iron ore.....	90
5. Blue aluminous shale and calcareous goniatite bed.....	85

* See statistical table at end of paper.

† "Geology of Bartholomew County," in Eleventh Ann. Rep. Dep. Geol. and Nat. Hist. of Ind., 1881, p. 174.

Of the shale No. 5 of the section Dr. Elrod wrote: "The blue aluminous shale, the equivalent of the New Providence shale of Prof. Borden, has a thickness ranging from 25 to 85 feet. It is locally known as a soapstone, and in structure is tolerably uniform, with a tendency to become ferruginous near the base. In places it resists the action of the atmosphere and water better than the higher drab colored shales. Where weathered it forms a blue plastic clay, and cold subsoil."

These lower Knobstone shales as a rule run higher in silica than in the region to the south, and will be found suitable only for building brick, either soft mud or dry pressed, or vitrified street brick. All the exposures of these shales are several miles west of the J., M. & I., the closest railway, and therefore not very available.

At Noble Hill, Jackson Township, the blue shale, No. 5, is exposed to a thickness of 20 feet, with 40 feet of soil and covered space above.

At Taylor Hill, Harrison Township, six miles southwest of Columbus, the exposure of blue shale is 85 feet thick, and is directly overlain with 90 feet of iron ore, shale and sandstone (No. 4 of the connected section). At the old Grass quarry, in the northeast quarter of section 24 (9 N., 4 E.), five miles west of Columbus, the exposure of blue shale is 47 feet in thickness, with heavy cover above. Many other outcrops occur in the Knobstone area west and northwest of Columbus.

Mr. F. M. Stevens, of Columbus, recently sent in to this office samples of a light gray, very siliceous clay, and also the same clay stained yellow with iron oxide. The white clay would, from appearance, run high enough in silica to burn into low grade refractory wares. At the same time, its percentage of clay base is sufficient to form the necessary bond. It seems remarkably pure for a surface clay, to be found in the region from which it came, which was a point three miles southwest of Columbus, in section 33 (9 N., 5 E.). Here, Mr. Stevens states, it is found in a very thick bed close to the surface over an area of one and a quarter acres. He had sample brick made from it which burned almost white in color, very heavy and smooth, and without any sign of shrinkage.

Three brick and four tile factories operate during the summer

season in Bartholomew County, all using the surface clays. Two of these are located at or near Columbus, the largest being that of F. T. Crump. At this yard, from four to six feet of surface clay is used in making ordinary brick. At two yards near Hope, drain tile and brick are made from surface clay two to three feet thick, with no stripping. At Elizabethtown a "black loam," four feet thick, is used in making drain tile, after stripping five inches of soil. At the yard of Chas. D. Glick, six miles southeast of Columbus, after stripping eight inches of top soil, "three feet of clay subsoil free from sand and gravel," are used in making drain tile.

SHELBY COUNTY.

This county, comprising an area of 408 square miles, adjoins Marion County on the southeast. It lies north of Bartholomew and Decatur, west of Rush and Decatur, east of Johnson and Marion and south of Hancock counties.

The Niagara Limestone of the Upper Silurian outcrops in numerous places along Flat Rock and Deer creeks in the southeastern corner of the county, but nowhere outside of their immediate valleys. About three-fourths of the area of the county, embracing the northern half and southeastern fourth, has for its surface rocks the Jeffersonville Limestone; while over the southwestern portion occurs the New Albany or Genesee Shale. Except along the streams, all rocks are covered with a heavy mantle of drift.

The only clays of the county are, therefore, of alluvial and drift origin. The latter occur in all parts of the county, being generally found in a stratum two to 15 feet in thickness beneath one to three feet of soil. Below the stratum of yellow loamy clay is usually one of sand or gravel. The following section of a well at Manilla will serve as an example of the general sequence of the surface strata in Shelby and eastern Rush counties:

Section of Well at Manilla.

	<i>Feet.</i>
1. Soil	3
2. Yellow loamy clay	7
3. Loamy sand	10
4. Boulder drift blue clay.....	47
5. Fine quicksand	3
6. Snow white sand	1
7. Gravel and sand.....	2

At Waldron the yellow clay is four feet thick beneath a similar thickness of soil and loam; at Flat Rock it is 10 to 15 feet in thickness beneath three feet of loamy soil. On the farm of J. M. Collins, one mile west of Mt. Auburn, the yellow clay is six feet thick. At Shelbyville it is replaced by an alluvial soil eight feet thick, which lies directly above a bed of gravel.

An exposure on Blue River, seven miles northeast of Shelbyville, gives the following:

Section of Bluff on the Billman Farm.

	<i>Feet.</i>
1. Soil	3
2. Yellow fluviatile clay	15
3. Glacial blue clay, with boulders and gravel	21

These various deposits of alluvial and drift clays can be made only into ordinary building brick and drain tile, as they contain too high a percentage of fluxes to withstand the heat necessary to vitrification. Some care must be taken to select clays free from lime and other pebbles, but otherwise good building brick can be made from almost any of the deposits. At the present time but three factories are utilizing these clays in the county. At the yard of A. C. Bowlby & Son, at Shelbyville, a "burr oak swamp clay," about four feet thick, is used for drain tile, the output being small. At that of James Brooks, in Noble Township, a "black clay, two spades deep," is also used for making tile after stripping six inches of surface.

JOHNSON COUNTY.

Just south of the center of the State is the county of Johnson, rectangular in shape, and comprising an area of 320 square miles. It lies south of Marion, north of Bartholomew and Brown, west of Shelby and east of Morgan counties.

The surface rocks of the county, which are nearly everywhere covered by a thick mantle of drift, are the New Albany or Genesee Shale of the Devonian and the Knobstone Group of the Lower Carboniferous. The former covers two thirds or more of the county, the Knobstone occurring only in the western third. The shales forming the lower portion of the Knobstone strata and the drift and alluvial clays occurring on the surface at various points present the only clay working materials of the county.

The principal exposures of Knobstone occur along the streams in the southwestern corner. The most eastern outcrop is at Woodruff Hill, south of Nineveh, southeast quarter section 34 (11 N., 4 E.). At Pritchard's Hill, in section 10 (11 N., 4 E.), there is another thick exposure in which numerous nodules of iron carbonate are mingled with the clay shales. In the deeper channels of all streams in Hensley, Union and White River townships, there are exposures of the shale. In general they are composed of loose, fine grained clay shales, which have become more siliceous toward the top. A number of these outcrops occur within less than half a mile of the Indianapolis Southern Division of the Illinois Central Railway, now in course of construction. Almost everywhere these shales contain ironstone concretions which would have to be thrown aside if the shales were put to use. In places, alternate layers of a more sandy shale or sandstone appear between the layers of clay shale, so that care should be taken in selecting a location for a factory to utilize the shales. At the junction of the two forks of Indian Creek, in the southeast quarter of section 20 (11 N., 3 E.), the following section occurs:

Section on Indian Creek, in Hensley Township, Johnson County.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil	2	0
2. Yellow surface clay.....	20	0
3. Gray to blue drift clay.....	30	0
4. Sandstone	0	10
5. Sandy knob shale.....	12	0
6. Sandstone	0	6
7. Blue clay shale	10	0
8. Sandstone	0	8
9. Blue clay shale	12	0
10. Paving stone (bed of creek).....	0	0

Nos. 7 and 9 of this exposure and similar shales of all other exposures in this region can be utilized for ordinary soft mud brick, for stiff mud stock brick, for dry pressed front brick, or for vitrified street paving brick.

Five factories are utilizing the surface clays of Johnson County* for making ordinary brick and drain tile. At Nineveh three feet of black and yellow clay are used, after stripping eight

*See statistical table at end of paper.

inches of soil. Both drain tile and brick are made, but only on a small scale, the value of the output in 1904 being \$1,350. At Franklin from 12 to 24 inches of surface clay are used in making soft mud brick. Near Whiteland a bed of "black and blue clay," 28 inches thick, is used for drain tile, and at Greenwood a yellow clay is used to a depth of 18 inches in making "common sand brick."

HANCOCK COUNTY.

This county, comprising an area of 307 square miles, lies just east of Marion and north of Shelby. Its entire surface is covered with a heavy mantle of drift, so thick that the underlying rocks nowhere appear, nor have any of the streams cut deep enough to expose them. Deep bores sunk for oil show that the Niagara Limestone immediately underlies the drift in the northeastern portion and the Jeffersonville Limestone of the Devonian in the remaining three-fourths of the county. Of the surface clays of the county Dr. R. T. Brown has written as follows:

"The upper surface drift clay of the county ranges from a pale cream color through yellow to orange in hue, and originally supported a heavy forest of beech and oak trees. On the more elevated lands, where this upper clay does not cover a superficial bed of gravel, it is generally from 15 to 20 feet thick, with a bed of sand or fine gravel separating it from the lower clay or till below. This sand or gravel is the water-bearing stratum that supplies most of the wells furnishing water for domestic purposes, watering stock, etc. This upper clay contains carbonate of lime in the form of sand and pebbles, from which the water, in percolating through it, becomes sufficiently charged with that substance to render it hard before it reaches the reservoir below.

"In the lowlands the upper clay is always thin and often entirely wanting. Here we have a stratum of vegetable loam from two to five feet thick, frequently resting directly on the till or lower blue clay. This clay, as it lies in its natural bed, is generally very compact and hard. When moistened and tempered it becomes quite soft and plastic, having an unctuous or talcose feel, and it is often so fine as to be profitably used in art modeling. When moist it has a blue or lead color, but when dry it assumes an ashy appearance. Though it appears to be a very pure

clay, yet a careful washing will show that nearly 50 per cent. of it consists of very fine grains of nearly transparent sand. The coloring matter is a sulphide of iron, which a red heat will convert into an oxide, and the color will be changed to a dark red.”*

These surface clays are used in making ordinary brick and drain tile at five or six yards in the county.† At Greenfield but two feet of clay can be used, as the lime pebbles become too numerous below that depth. At Maxwell “one spade of soil and two spades of clay are used, after cutting off about four inches of sod,” while at Gem, after removing six inches of stripping, a blue clay two feet thick is used for drain tile.

MARION COUNTY.

Marion County lies near the center of the State, with Indianapolis, the State Capital, as its county seat. It comprises an area of 400 square miles, lying east of Hendricks, south of Hamilton and Boone, west of Shelby and Hancock, and north of Johnson and Morgan counties. The West Fork of White River passes through the county from north to south near its center. This stream is bordered in many places by a broad gravel plain or river terrace, which ranges from one to three miles or more in width, and rises gradually into the uplands.

The entire surface of the county is covered with a thick sheet of compact till. In a few places the underlying rock occurs within 30 to 50 feet of the surface, but over much of the area the drift exceeds 100 feet, and in a few places is known to be above 225 feet in thickness.

The water in the surface wells in the county is usually obtained in sand beds at a depth of 10 to 20 feet, near the junction of the yellow and blue surface clays. Drilled or tubular wells are in many places sunk through the blue clay to gravel deposits, at a depth of 100 or more feet.

The following well records, showing the thickness and sequence of the components of the drift in Marion County, are taken from Dr. R. T. Brown’s “Report of a Geological and Topographical Survey of Marion County, Indiana” :‡

* “Geology of Hancock County.” In Fifteenth Ann. Rep. Ind. Dep. Geol. and Nat. Hist., 1885-86, p. 191.

† See statistical table at end of paper.

‡ Ind. Dep. Geol. & Nat. Hist., 12th Ann. Rep. 1882, p. 91.

Section of Well at Butler University, Irvington.

	<i>Feet.</i>
1. Yellow clay and loam	18
2. Blue clay	18
3. Quicksand (water)	4
4. Blue clay	60
5. Coarse gravel (water)	8
Total	108

Section of Well at Brightwood.

	<i>Feet</i>
1. Loam and yellow clay.....	22
2. Sand (water)	2
3. Blue clay	36
4. Fine sand (water)	3
5. Blue clay	40
6. Coarse gravel	4
Total	107

Section of Well in University Park, Indianapolis.

	<i>Feet.</i>
1. Loam	3
2. Gravel to water	17
3. Gravel below water.....	20
4. Blue clay	25
5. Coarse gravel	2
Total	67

The surface yellow clay is utilized for making soft mud brick at ten different yards at various points in the environs of the city of Indianapolis.* At most of these it is used twihout stripping to a depth of 18 to 30 inches. Aside from these brick yards, the only clay-working industries in the county are the extensive ones of the U. S. Encaustic Tile Co. and the Indianapolis Terra Cotta Co., both of which import all their clays from other parts of Indiana and different States of the Union.

BOONE COUNTY.

The southern edge of this county is about 10 miles northwest of Indianapolis. It lies north of Hendricks and Marion and east of Montgomery County, and embraces an area of 420 square miles.

*See statistical table near end of paper.

The entire surface of the county is covered with drift to a depth of 75 to 200 feet, there being not one exposure of the underlying rocks within its bounds. Deep wells and bores have proven the greater portion of the county to be underlain with the black New Albany Shale of Devonian age. The Jeffersonville Limestone occurs as the surface rock in deep bores in the northeastern corner, while the Knobstone has been found in a number of wells in the western third.

The yellow surface clay of the drift lies from two to five feet below the top of the surface soil, and runs from 4 to 20 feet in thickness. It usually overlies a thin layer of sand or gravel, beneath which is a stratum of blue clay, which runs anywhere from 3 to 25 feet thick. The following section of a well on the farm of D. M. Burns, two miles north of Lebanon, will show the general sequence of the upper portion of the drift in the county.

Section of Well on Burns Farm, North of Lebanon.

	<i>Feet.</i>
1. Soil	2
2. Yellow clay	7
3. Gravel and sand	2
4. Blue clay	22
5. Gravel	2
6. Gravel and clay	3
7. Blue clay	50
8. Boulder	1
9. Blue clay	23

Soft mud brick and drain tile are made from the surface clays at a number of localities in the county.*

At Lebanon from 24 to 36 inches of yellow surface clay is used, after stripping 8 to 10 inches of soil. At the yard of Saunders & Robinson, seven miles northeast of Lebanon, the top soil, two to six inches thick, is removed, and about 20 inches of the underlying clay used in making drain tile.

CLINTON COUNTY.

This county, comprising an area of 402 square miles, lies north of Boone and east of Montgomery and Tippecanoe counties. Like Boone, its entire surface is covered with a thick glacial deposit of

*See statistical table at end of paper.

clay, gravel and sand. The only knowledge of the underlying rocks comes from deep bores which have passed through this mantle in search of water, gas or oil. These show practically the entire county to be underlain with rocks of the Devonian age, the eastern limits of the Knobstone passing across the extreme southwestern corner a mile or so east of Colfax. All clay deposits of the county are, therefore, of drift or alluvial origin, and suitable only for common brick and drain tile. The following general account of the soils and clays is taken from W. H. Thompson's report on the geology of the county:*

"The soil of Clinton County is, for the great part, a black, fertile mold or loam, well mixed in places with fine sand, especially toward the southern part, where the prairie gives place to gently rolling timbered land. Such diggings and borings as have been made through this soil have reached the blue clay or till a few feet below the surface. Wherever yellow clay is found it overlies the blue. Both of these clays contain a large amount of gravel and crushed stone, but the blue is more compact and silicious than the yellow.

"In many places along the streams of the county there are bold bluffs of the bluish-gray boulder clay, sometimes obscurely stratified, showing partings of fine buff sand. It is not infrequently the case that a sheet of this sand will be overlaid with a thickness of 10 or more feet of refractory "hardpan;" that is, intensely solidified blue clay, practically impervious to water. This geological feature of the county is the source of the fine flowing wells which supply the beautiful and thriving city of Frankfort with an excellent quality of chalybeate water in exhaustless quantities."

Marly or silty clays occur in places near or on the sites of old marshes or extinct lakes. On the land of F. M. Kemp, one mile south of Frankfort, west half of northeast quarter of section 22 (21 N., 1 W.), a bed of such clay occurs beneath a tract of 15 or more acres. It is light gray in color, very fine-grained, and overlain with three and a half feet of black muck soil. The bed of marly clay, where tested, was 22 inches thick, and lies on top of a thick deposit of blue drift clay. By itself it can be burned into

*Fifteenth Rep. Ind., Dep. Geol. & Nat. Hist., 1886, 154.

terra cotta lumber or hollow fireproofing. Combined with the underlying blue clay, it will make drain tile or hollow building block of good quality.

Ordinary brick and drain tile are made at a half dozen or more factories in Clinton County. The largest of these is that of the M. J. Lee Drain Tile Co., at Colfax, in the southwestern corner of the county. Four inches of black soil are here stripped and the surface clay then used to a depth of four feet. Drain tile 4 to 30 inches in diameter are made, the value of the output in 1904 being \$36,500. At Michigantown three feet of blackish clay are used in making drain tile, while at Frankfort soft mud, sand-molded brick are made from two feet of yellow clay, too many lime pebbles being encountered below that depth.

CARROLL COUNTY.

This county, embracing an area of 370 square miles, lies north of Clinton and east of Tippecanoe and White counties. The Wabash River cuts through it in a general southwesterly direction, leaving about one-fourth the area in the form of a rough triangle, to the northwestward.

The rocks of three geological epochs are represented in Carroll County. The Niagara Limestone of the Upper Silurian covers an area of about 25 square miles near the center of the eastern third, and also occurs along the northern border and over a small area just north of Delphi, the county seat. The remainder of the county is about equally divided between the Jeffersonville Limestone and New Albany Black Shale of the Devonian Period, the limestone being found in the eastern and northern portions and the shale in the southern and western.

Almost the entire surface of the county is covered with a heavy drift deposit, but the Wabash River and some of its larger tributaries have in places cut through this and exposed the underlying limestones and black shales. The only clays of the county are of drift origin, or in part formed from the decomposition of the black shale. Prof. Collett, in the report of this department for 1872, has the following to say of these clays:

"The clays of Carroll County are largely composed of the pulverized *debris* of the black slate. This gives plasticity to the

material and adds a perceptible amount of iron, which paints the bricks here made with an indelible, ruddy color. A stranger will at once notice that the city of Delphi has the appearance of a new town. Although some of the houses have been exposed to the weather for 25 years, the brick walls are as fresh and brightly colored as of yesterday. This building material deserves the notice of architects, as it is believed to furnish a product equal to any in the Union."

At the present time these clays are used for soft mud brick only at Ockley and for drain tile at Bringhurst. At the former place a surface clay 18 inches thick is utilized. At Bringhurst, after stripping two to six inches of sod and soil, the underlying clay, 18 inches thick, is used.

TIPPECANOE COUNTY.

Tippecanoe County is situated in the west-central part of the State, and is bounded on the north by White and Carroll, on the east by Carroll and Clinton, on the south by Montgomery, and on the west by Fountain, Warren and Benton counties. It is separated from the boundary line of the State of Illinois by the three counties last named. The county is 21 miles wide from east to west and 24 miles in length from north to south, its area being 504 square miles. About one-half of the surface consists of broad, fertile and nearly level plains. The balance consists of gently rolling uplands, steep hillsides or rich alluvial bottoms. Occasional swamps or bogs are seen, with deep lacustral deposits.

The surface rocks of the county are almost everywhere hidden by a heavy mantle of drift, which ranges in known thickness up to 350 or more feet. Beneath this drift the New Albany Black Shale is found over the northeastern portion of the county, while the Knobstone and limestones of Lower Carboniferous age occur in the southern and western portions. Near the center of the western margin the Mansfield sandstone is also known to occur beneath a small area.

While the Knobstone rocks which elsewhere furnish an abundance of clay-working material, occur over a large area of the county, they are everywhere so deeply buried beneath the drift that they cannot be utilized. The only workable clays of the

county are, therefore, of drift origin. In the central and northern parts of the county extensive beds of sand and gravel occur close to the surface, and brick clays are not common, but in the southern and eastern portions the characteristic yellow and blue clays of the drift are everywhere abundant. In the vicinity of Crane the well sections exposing these clays run about as follows:

Section of Well One and a Half Miles Southwest of Crane.

	<i>Feet.</i>
1. Soil	2
2. Yellow clay	7
3. Blue clay	8
4. Gravel	1

At Stockwell the yellow clay runs about 12 feet in thickness, with gravel immediately below, while at Monroe the yellow clay immediately overlies the blue, each with a thickness of 13 feet. Near Dayton the yellow clay runs as high as 28 feet in thickness. At Montmorenci it is six feet thick and overlies a 25-foot stratum of the blue. At Battle Ground, north of Lafayette, both clays are wanting, the soil resting directly upon hardpan, beneath which is 75 feet of gravel.

Brick and drain tile are made from these surface clays at Lafayette and Montmorenci.* At the former place Jacob May & Son have two large yards. At the one on South Fourth Street 18 inches of surface clay are used in making soft mud sand-molded brick, the output in 1904 being 1,500,000, valued at \$8,250. At the yard on South Ninth Street, three feet of clay are used in making stiff mud brick and drain tile, 1,000,000 brick and 180,000 tile, together valued at \$9,100, being produced in 1904.

At Montmorenci, Henry Kneale makes drain tile from a mixture of black prairie top soil, 10 to 12 inches thick, and underlying blue "joint clay." He writes: "We dig about three feet in all and mix the blue and black together. It makes a good mixture and the tile give good wear."

*See statistical table at end of paper.

WHITE COUNTY.

This county lies north of Tippecanoe and Carroll and east of Jasper and Benton, and comprises an area of 500 square miles. The greater portion of its surface is underlain by rocks of the Devonian age, the New Albany Black Shale being the principal formation. The Niagara Limestone occurs in the northern and northeastern portions and outcrops near Monon, while the Knobstone underlies a small area in the southwestern corner. Almost everywhere these rocks have above them a heavy cover of drift. The only rock exposures are those of the Niagara Limestone, already mentioned, near Monon, and one of black shale near the Norway dam on the Tippecanoe River.

The only clays of workable quality in the county are those of drift origin. These are utilized for drain tile at Chalmers, Idaville and near Monon.* At the first-named place the tile are made from "about three feet of the clay, after removing eight inches of top soil." At Idaville a tough, bluish clay is used, 10 inches of black soil being first removed.

At the yard three miles east of Monon a surface clay, three and a half feet thick, is used for brick and tile, after stripping about six inches of drab sandy loam.

The remaining counties in which the Devonian rocks form part of the surface, viz., Jefferson, Decatur, Rush, Hamilton and Cass, have the greater part of their areas covered by the rocks of the Upper Silurian Period, and hence will be treated in that connection.

*See statistical table at end of paper.

IV. COUNTIES OF THE UPPER SILURIAN AREA.

The list of counties forming this area was given on page 45. Of those there named the clays of White, Hancock and Jennings have already been discussed, since the greater portion of their respective areas is covered with rocks of Devonian age. As already noted, the only commercial clays of the large area covered by Upper Silurian rocks in Indiana are those of drift or alluvial origin. These can be used only for the cheaper clay commodities, such as ordinary brick and drain tile.

CASS, MIAMI, WABASH, HUNTINGTON, WELLS AND ADAMS COUNTIES.

These six counties comprise a combined area of 2,300 square miles, lying along and on both sides of the Wabash River, between White County and the Ohio State line. With the exception of a small portion of Cass County, in which the Jeffersonville Limestone forms the surface, their entire area is underlain by the Niagara Limestone of Upper Silurian Time. This limestone is exposed at a number of places along the Wabash and near the mouths of the larger tributaries which enter that stream in the region under consideration. However, in by far the greater portion of the area the limestone is covered by hardpan, gravel, sand, yellow clay and soil to a depth varying from 26 to 450 feet. Many deep bores for oil and gas have been sunk within the past twenty years through this cover of drift and the underlying rock, and hence the nature of the latter is well understood.

The surface clays of the counties mentioned are utilized for brick and tile-making at a number of localities,* while at many places occur deposits suitable for such wares, which have not yet been developed.

In Cass County a layer of gravel usually occurs immediately below the top soil. In places a layer of yellow clay, 3 to 15 feet thick, replaces the gravel. This sometimes overlies blue clay, but more generally sand or gravel. At Logansport 24 inches of surface clay is used without stripping for making common brick, the output in 1904 being two millions.

In Miami County there is a fine deposit of clay on the farm of

*See statistical table at end of paper.

Abram Alley, four miles northwest of Denver, on Weasaw Creek, that might be profitably used in the manufacture of pottery, and is certainly valuable for the manufacture of tile and brick. It burns to a light cream color, stands the fire well, does not warp materially, and may be burned to any degree of hardness. On the same farm occurs a vast quantity of a brownish-colored clay, which burns to a bright red and makes a most excellent paint. This same variety of clay occurs also on the farm of Louis Piper, two miles north, and on the farm of William Zook, one mile north of Denver. It also occurs in the vicinity of Chili in inexhaustible quantities.

Brick or tile factories are in operation in this county at Peru, Amboy and Perrysburg. At Amboy a lowland alluvial surface clay is used to a depth of three feet, after removing three to six inches of loam soil. At Perrysburg eight inches of sandy clay are stripped and the underlying surface clay then used to the depth of six feet in making drain tile and brick.*

In Wabash County the surface wells in most places penetrate from 3 to 20 feet of yellow clay, beneath a foot or two of soil. Underlying the yellow clay is usually a thick stratum of blue clay, below which is gravel, forming the water-bearing stratum. The yellow clays are utilized for brick or tile at Wabash, La Fontaine and North Manchester. At the last-named place six feet of tough yellow clay are used for making ordinary brick, after removing three inches of soil.

At La Fontaine soft mud brick are made from 10 to 30 inches of surface clay, after removing the grass roots. At the yard of E. H. Carothers, seven miles north of Wabash, "a good black surface clay" is used for drain tile, after stripping six inches of sod and soil.

In Huntington County the mantle of drift averages thinner than in those adjoining, but yellow clays, suitable for brick or tile making, occur in a number of places. At Huntington, the surface clay used for brick-making runs 16 to 30 inches in thickness, with practically no stripping. Below 30 inches the clay becomes "too strong, with some lime pebbles in it." At the yard of Tribolet Bros., five miles southeast of Huntington, a stripping of eight

*See statistical table near end of paper.

inches of soil is removed two or three days before the clay is used. The latter is "a heavy, smooth clay," 26 inches of which are made into drain tile and brick. At Bippus, after removing about six inches of soil, a stratum of blue clay from four to six feet thick is made into building brick and drain tile. In the yard at Majenica a similar blue clay, three feet thick, is used for the same products, after stripping six inches of the overlying surface.

In Wells County the thickness of the drift is moderate, the underlying limestone being struck in many places at 30 to 50 feet. At Bluffton "a dark low-ground surface clay" is made into drain tile, the thickness used being four feet, without stripping. One mile south of Bluffton a light yellow clay, 8 to 24 inches thick, is burned into soft mud brick. In a yard at Poneto five inches of soil are removed and a dark clay, averaging five feet in thickness, is used for drain tile.

The Aurora Fire Clay Co., at Bluffton, have the largest clay-working industry in the county. They make glasshouse supplies from fire clays which are secured from the Christy Fire Clay Co., of St. Louis, Mo. From 300 to 500 tons of the clay, costing from \$12 to \$17 per ton delivered, are used each year. The output of the factory in 1904 was 550 glass pots, valued at \$15,000.

In Adams County the majority of surface wells are sunk through yellow and blue clay to a depth of 20 to 45 feet. Brick and tile are burned at Decatur, Monroe and Berne.* At Decatur the clay suitable for use runs two to six feet in thickness, with little or no cover, while at Berne it averages about five feet, with two inches of necessary stripping above. At Monroe, hollow building block are also made, the surface clay being used without stripping to a depth of four feet.

JAY, BLACKFORD, GRANT AND HOWARD COUNTIES.

These four counties lie in an east-west line, between Carroll County and the Ohio State Line, near the northern part of the Upper Silurian area. Together they comprise 1,248 square miles. With the exception of a small area in southwestern Howard, over which the Jeffersonville Limestone occurs, the Niagara Limestone form the surface rock. As in the counties to the north, it is nearly everywhere overlain with a thick covering of drift, com-

*See statistical table at end of paper.

posed of soil, clay, gravel, hardpan and sand. The strata of these component materials of the drift vary exceedingly in different parts of the region, both in sequence and thickness. All clays suitable for burning are drift or alluvial in character, and fitted only for the making of low grade clay wares. Each of the counties has from two to a half dozen yards at which brick or drain tile are made.*

In Jay County the drift averages about 80 feet in thickness, the greater part of which is composed of a stratum of blue clay. Just east of Portland wells are sunk only to a depth of 12 to 20 feet, water being found in a sand which lies between a yellow and blue clay. The surface clays are used for brick or tile at seven yards in the county. At the yard of the Portland Hollow Brick Works a bed of alluvial second-bottom clay three to five feet thick is used on a large scale for drain tile and hollow building block, the value of the output in 1904 being \$45,000. At Boundary the same products are made from a 10-foot deposit of similar clay. At the yard of H. Z. Huey, in Wabash Township, in the northeastern part of the county, black clay to the depth of eight inches is stripped and the underlying stratum, four feet thick, used for drain tile, brick and hollow block. Near Redkey "ordinary surface clay," five feet in thickness, is used for the same class of products, while at the Bryant yard, and also a yard near Greene, four inches of surface is stripped and the underlying clay used to a depth of four feet.

The drift covering of Blackford County runs from 100 to 150 feet or more in thickness. It is composed mainly of a compact till of yellow and blue clays and hardpan, though beds of sand and gravel are sufficiently numerous to supply water for most of the wells at moderate depths. At Hartford City a yellow, loamy clay, two to five and a half feet in thickness, is used for drain tile and hollow block, after removing two inches of grass roots and soil.

Grant County possesses an abundance of surface clay suitable for brick and tile. Several important factories for utilizing these clays have been in operation for a number of years, and during the time that natural gas furnished an abundant supply of cheap fuel the output was very large.

*See statistical table at end of paper..

The principal one of these factories is that of the Marion Brick Works, located on the Michigan Division of the Big Four Railway, three miles south of Marion. This factory started in 1888, soon after the discovery of natural gas, to make soft mud brick from the surface drift clay. For sixteen years its annual output has averaged 20,000,000, or 400,000 per week. These have been shipped mostly to points in central and Northern Indiana, Ohio and Illinois. In 1904 they brought \$6.00 per thousand f. o. b. the cars at the plant. The company owns 375 acres of land and has under lease 80 acres additional. About 160 acres of this was covered with clay, which, after removing the sod, they use, as needed, to a depth of 30 inches. About six acres are used each year, and about 60 acres, sufficient for 10 years' output, still remain. As fast as the clay is removed the land is manured and clovered, and is soon brought up to near its former standard of fertility.

The clay is a grayish yellow in color, rather coarse-grained, tough and very plastic when worked. It makes a durable brick, dark cherry red in color. At a depth below 30 inches it contains numerous line pebbles which prevent its use. At the present time it is being hauled on tram cars from a distance of nearly a mile by dummy engine. At the plant it is run through a disintegrator, then elevated and passed through Potts machines, where it is tempered and pressed. Three of these machines are in use, each requiring eight men to operate. These receive $6\frac{3}{4}$ cents each per thousand brick, and all employes, of whom there are about 100, are hired on the same basis. The brick are dried 72 hours by direct steam heat and are burned seven to eight days. The time of burning has been reduced nearly one-half by the use of the Boss system, which was installed in 1904. Gas was used as fuel up to the fall of 1903. Linton (Greene County) coal, costing \$2.20 per ton laid down, is now used, 130 tons being required to burn 400,000 brick. It is claimed that 98 per cent. of the brick coming from the kilns are sold. The bats and culls are reground in a dry pan and mixed with the other clay. The brick, wherever used, have given good satisfaction, the demand having been, for the most of the time, far in excess of the supply.

A mile and a quarter south of Jonesboro the Citizens' Brick Co. began making soft mud brick from surface clay in May, 1903, the

plant being located on a switch of the Big Four Railway. The clay used is secured from the site of an old orchard 250 feet south of the factory. The sod and surface to the depth of five inches is stripped and 30 inches of the underlying gray to buff clay then loaded on tram cars and hauled by horsepower to an Anderson crusher. After passing through this it is pugged and made into brick on a Potts machine. When running full capacity—30,000 daily—60 tram carloads of the clay are required. Below the 30 inches used the clay contains too high a percentage of iron oxide and lime, and brick made from it check in drying. The company owns 21 acres of the clay-covered land and estimate that it will last seven years. Some trouble was experienced in the summer of 1904 in securing a plentiful water supply, and the plant was shut down for a month or longer.

The brick are dried with steam and burned with coal, Linton egg coal, costing \$1.90 per ton, laid down, being used. One hundred and fifty tons are required to burn 375,000 brick. It is unloaded from the flat cars directly into small tram cars, which are run between the kilns and dumped close to the arches. Molding sand is secured from Sandusky, Ohio, and costs \$1.70 per ton at the plant. The brick require 15 days for burning. They are a uniform dark red in color and appear of good quality, being hard and tough, with sharp edges. They bring \$6.00 per thousand at the plant. All hands except the burners are paid by the thousand brick, the men in the pit and brickmakers receiving 7 cents, setters 45 cents and loaders 30 cents per thousand. The brick are sold mainly at Indianapolis, Marion and other cities tributary to the Big Four System in central and northern Indiana.

At the Bolen Brick Company's hand yard, in North Marion, surface clay about 20 inches thick is used, the output in 1904 being nearly two and a quarter million, while at Sweetzer about "four spades" (32 inches) of clay from "elm flats" are mixed without stripping and used for drain tile. At Herbst two inches of top are stripped and 2½ to 3 feet of black loam used for drain tile.

The coating of drift in Howard County averages about 75 feet in thickness. Outcrops of the underlying rock occur at Kokomo and on Wildcat Creek. Surface wells often find an abundance of

water at 15 to 20 feet in beds of gravel or sand, between yellow and blue clay. The following section of one four miles southwest of Kokomo may be taken as an average:

Section of Well Four Miles Southwest of Kokomo.

	<i>Feet.</i>
1. Soil	2
2. Yellow clay	14
3. Sand and gravel	3
4. Blue clay	36

At Russiaville, in the southwest part of the county, the drift is 156 feet in thickness, and presents the following section:

Section of Bore Through Drift at Russiaville.

	<i>Feet.</i>
1. Soil	2
2. Yellow clay	10
3. Sand with water.....	4
4. Blue clay	40
5. Sand and gravel with thin beds of blue clay.....	100

The surface clays of the county are utilized for brick-making at Kokomo and for tile-making at Greentown and New London. At Kokomo J. M. Leach & Co. strip four inches of sod and soil and use 32 inches of underlying yellow clay in making common brick. At Greentown a yellow clay, 18 to 20 inches in thickness, is used for brick and a "blue or swampy clay, three to five feet thick, for drain tile." At New London, after stripping one spade of black loam, a surface clay, averaging four feet in thickness, is used for tile, hollow block and brick.*

**TIPTON, HAMILTON, MADISON, DELAWARE AND RANDOLPH
COUNTIES.**

These five counties comprise an area of 1,967 square miles, lying just northeast of the center of the State, between Clinton and Boone counties and the Ohio State line. Portions of the western thirds of Tipton and Hamilton have for their surface rocks the Jeffersonville Limestone of the Devonian Period. Otherwise the entire area of the counties under consideration is underlain with Niagara Limestone of the Upper Silurian. This limestone is everywhere, except along a few of the streams, covered

*For additional information regarding these yards see statistical table near end of paper.

with a heavy mantle of drift. This has been pierced in hundreds of places during the past 20 years by bores sunk for gas and oil, and its thickness found to range from five up to 400 feet. All clays suitable for manufacturing are either the yellow or blue till clays, dumped where they now lie by the melting glacier, or these clays, sorted and modified and redeposited by the flowing post-glacial streams of the region.

In Tipton County the drift overlying the surface rock runs 75 to 100 feet in the eastern and 200 to 300 feet in the western portions. On the east border of the county, in the vicinity of Elwood, its upper portion is mainly a blue clay intermingled with beds of sand and gravel.

Three miles east of Tipton a gas boring showed the drift constituents to be arranged as follows:

Section of Bore Three Miles East of Tipton.

	<i>Feet.</i>
1. Soil	2
2. Yellow clay	9
3. Blue clay	27
4. Gravel	5
5. Blue clay	45
6. Gravel	15

At Kampton, in the western part, the yellow clay immediately below the surface is 10 feet thick, this being underlain with sand and blue clay in alternating layers to a depth of 175 feet.

Ordinary brick and drain tile are made at six yards in the county.* Two of these, located at Tipton, make ordinary brick from about 30 inches of grayish yellow surface clay, used without stripping. At Goldsmith and Hobbs about four feet of similar clay is used, after removing three to five inches of sod and soil. At Curtisville an alluvial clay, 12 to 20 inches thick, is used for drain tile, while at Windfall brick and drain tile are made from a surface yellow clay, after removing four inches of soil.

In Hamilton County the drift runs from 10 to 250 feet or more in thickness, the upper portion being principally a compact till of yellow and blue clays and hardpan. In small areas bordering the valley of White River this till is replaced by gravel and sand. Brick and tile are made from these clays at three yards in the county.* At the Arcadia Brick Works, at Arcadia, 18 to 30

*See statistical table at end of paper.

inches of grayish yellow surface clay are used without stripping in the making of soft mud red building brick. The output of this factory in 1904 was six million brick, which brought an average of \$5.00 per thousand f. o. b. the cars. At Noblesville two feet of clay, also without stripping, are used for hand-made brick.

At the yard of Chas. Jessup, three and one-half miles west of Arcadia, "a blue-gray surface clay, on the blocky order, 36 to 40 inches in thickness," is used for drain tile, after stripping five to eight inches of black loam.

In Madison County the surface Niagara rock is frequently encountered at depths of 50 feet or less, but occasional borings in old pre-glacial valleys have passed through 150 or more feet of drift. The grayish yellow surface clays of this county are used on an extensive scale in two of the largest brick and tile-making plants in the State and on a smaller scale at two or three other places.

One mile northeast of Summitville, on a spur of the Big Four Railway, Mr. S. C. Cowgill began, in 1880, the making of drain tile from a surface drift clay. The business gradually grew, and in 1894 a second plant was built about 150 yards from the first. The two were operated under the name of the Summitville Tile Works until May, 1902, when the company was reorganized as the National Drain Tile Company, with a paid-up capital of \$150,000. This company now operates four large plants in Indiana, three of which have been previously mentioned,* the four having a total annual capacity of 4,000 carloads of tile.

At Summitville the clay used is obtained about a mile and a half northeast of the plant, being hauled there in tram cars by a dummy engine. Thirty cars, each holding three and a half cubic yards, are used each day. After stripping a few inches of grass roots and top soil, the remaining soil and underlying clay is used to a depth of 32 inches, below which the clay contains too high a percentage of lime. The first 40 acres, southeast of the plant, from which the clay was stripped was sold for \$1,400, and is now used for farming purposes. A second 40 was purchased for \$65 per acre, from which the company now derives its clay. The soil used is a dark gray loam, while the clay is of a bluish hue, stained with oxide of iron. The mixture burns a bright red, and forms a

*See pp. 106, 142, 161. Also statistical table at end of paper.

product which has become widely known as the standard of its kind.

At the plant the clay is run through a crusher and then into a pug mill. As it issues from the latter the smaller tile are made directly from it on a table, but that for the larger tile is elevated to the top of a sewer pipe press on the third floor. The tile emerge from the press on the second floor and are taken to the drying rooms, where they are subjected to steam heat—exhaust by day and direct by night—for an average of six days. Not more than 70 per cent. of those coming from the press finally reach the market, as a large number crack in drying, and there is some loss in burning. The clay is much tougher than the Carboniferous shales used at the other plants of the company, and the unburned ware will therefore stand handling better, but it cracks much more freely in drying. If the shale tile were tough like the drift clay they would be so much better, or if the drift clay tile would stand air and heat like the shale tile the loss would be much less.

The tile run in size from 4 to 20 inches, the larger sizes being dried on the upper floors. The kilns used are 15 in number, of the round down-draft pattern, and erected close to the factory, so that the larger tile can be run down an inclined plane to the door of the kiln. The burning occupies four days, and since 1903 Linton Greene County lump coal, costing \$1.90 per ton laid down, has been used as fuel, 15 tons being required to burn each kiln of ware. Of the 65 men employed, all are hired by piecework, receiving from 15 to 17½ cents per hour, but so many pieces constitute an hour's work. For example, eight and a third hours' time are allowed for emptying or filling a large kiln, and the making of 55 18-inch tile constitutes an hour's work at the press. The average output per week is 12 kilns of finished tile, valued at \$300 each. That average was kept up for eight years without a break when gas was used as fuel. One gas well, costing about \$1,500 completed and fitted up, ran all the kilns for that time, but it gave out in 1903. A plentiful supply of water is secured from a gravel stratum 60 feet below the surface, a well being located at each plant.

At Anderson the Indiana Brick Co. has one of the most up-to-date plants in the State for the making of ordinary soft mud

brick. It is located two and a half miles southeast of the city, on a tract of 208 acres owned by the company, which lies adjoining the Pennsylvania, Big Four and Central Indiana railways. Brick-making began in 1901, the clay used being a fine-grained, buff-colored, loamy material, which is of high grade for a surface clay in this region of the State. From 28 to 36 inches are used, from the grass roots down, lime pebbles beginning to appear below that depth. Using to this depth, about 15 acres of this land is stripped each year to make 22,000,000 brick. The clay is at present hauled in wagons, but a tramway will be put in as soon as the pit is opened any distance from the plant. The clay is run through a disintegrator and then made into brick on Potts and Hercules machines, the output being 80,000 per day, or 22,000,000 in 1904. From the machines the brick are first passed to a tempering room and exposed to a temperature of 95 to 110 degrees for 24 hours. From there the cars are wheeled into drying rooms, where the temperature is 120 to 130 degrees. Here they are kept two days, steam heat being used in both places. The burning is done with both natural gas and coal, the former being used for water smoking and in part for burning. In September, 1904, the gas was being secured from several miles south of Anderson, and cost 11 cents per thousand cubic feet, or about \$2,000 per month. On kilns holding 400,000, with 56 fires going, a back pressure of three pounds furnished sufficient gas. With gas the brick are burned in 13 days; with coal in 16 days.

The hands, of whom about 100 are employed, work by piecework, at so much per thousand, and make from \$2.00 to \$3.00 per day, averaging \$2.25. The brick are of a uniform dark red in color, close-grained, tough and durable. They cost about \$4.00 per thousand on board the cars, and sell at \$6.00, the demand being greater than the supply.

At Orestes, in the northern part of Madison County, four feet of soil and grayish yellow clay are mixed and used in making drain tile from 4 to 18 inches in size. These tile are burned four days with Linton coal, costing \$1.90 per ton. At Summitville and Shirley 18 to 24 inches of surface clay are used for brick-making, no stripping being required.

In Delaware County the drift runs from 20 to 200 feet in

thickness, and probably averages about 60 feet. At Selma, in the eastern part, a gas bore showed 92 feet, divided as follows:

Section of Bore at Selma.

	<i>Feet.</i>
1. Soil and yellow clay.....	12
2. Sand with water.....	8
3. Blue clay	12
4. Sand and gravel	60

Brick and tile are made at five yards in the county,* the two largest being located near Muncie. At the yard of the Bennett Brick Co., two miles north of the city, the clay, from the grass roots to a depth of 24 inches, is used for soft mud brick, lime pebbles appearing below that depth. After drying 48 hours in direct heat dryers, the brick are burned 16 days with Linton coal as fuel. The output in 1903 was five millions, in 1904 three millions, the decrease being due, according to the superintendent, to the fact that "any man in Muncie who had 50 cents was buying oil stock instead of investing in building." The brick are more porous and friable than those burned at Anderson.

At the yards of the J. D. Mock Brick Co., three miles southeast of Muncie, a fine-grained gray surface clay is used, which runs 28 inches in thickness, with hardpan beneath. The output is 30,000 daily for ten months in the year. Drying is done by direct heat, in a 14-tunnel "trolley dryer," the brick being loaded on swinging racks instead of cars, the racks being suspended in the tunnels from an overhead rod. Linton coal, costing \$1.15 at the mine, 75 cents freight and \$3.00 per car switching charges, is used as fuel, the total cost being about \$2.00, laid down. The burning takes 12 to 14 days, the Boss system being in use. The brick from both the Bennett and Mock yards are sold through one office and are mostly used in Muncie, bringing \$6.75 per thousand, delivered, or \$6.25 on board cars. All hands work by piecework, and average \$1.75 per day.

The drift of Randolph County runs from a thin coating up to 340 feet in thickness. It is in general a gray or yellowish clay near the surface, with blue clay, sand and gravel in the deeper portions. From 10 to 30 feet of clay are usually passed through before reaching gravel. At Union City the water of the surface

* See statistical table at end of paper.

wells is obtained in gravel beneath blue clay at a depth of 35 feet. At Winchester the more shallow wells strike water in gravel after passing through 12 to 14 feet of clay. At Farmland and Parker, in the western part, the surface clay runs eight to twenty feet in thickness. Only the upper two or three feet of clay is free enough of lime pebbles to be burned into brick or tile, but the clay of almost any locality in the county can be used to that depth. Local tile mills to the number of 17 or 18 were formerly in operation in this county,* but at present but three factories are making brick or tile within its bounds. At Winchester the surface clay to a depth of four feet is used for soft mud building brick, while at the yard of B. H. Strahan, six miles northwest of Winchester, "six inches of soil and five feet of underlying clay, without stone or gravel," are made into drain tile. At Stone Station four feet of loamy clay are used for tile, after removing six inches of surface.

HENRY, RUSH, DECATUR, RIPLEY AND JEFFERSON COUNTIES.

These five counties comprise 1,994 square miles, lying along the eastern edge of the southern half of the Upper Silurian area. The western portions of Rush, Decatur and Jefferson counties are partially underlain with the Jeffersonville limestone of Devonian Age, while the New Albany Black Shale also outcrops in the southwestern part of Jefferson. The Ordovician or Lower Silurian shales and limestones form the surface over small areas of Decatur and Jefferson and much of the eastern half of Ripley. The Niagara Limestone of the Upper Silurian is, however, the prevailing rock over the greater part of each of the five counties.

The mantle of drift above the surface rocks gradually decreases in thickness from north to south, and south of Henry County seldom runs over 100, and averages less than 50 feet. The southern limit of the Wisconsin drift sheet passes diagonally across Decatur County, and all of the area to the south is covered only with the débris of the Illinoian invasion. Many outcrops of the surface rocks appear along the streams, especially in the southern part of the area, but no one of these is suitable for clay-burning purposes. The only clays which can be so utilized are, therefore, of drift or alluvial origin.

*Phinney, 12th Rep. Ind. Geol. Surv., 1882, p. 191.

Henry County has, perhaps, the thickest drift in the State, one well near Newcastle having penetrated 500 feet before striking rock and one at Cadiz more than 400 feet. This great thickness is mainly composed of a compact blue clay. One of the more shallow water wells sunk in the valley of Blue River near Newcastle showed the drift constituents to be arranged as follows:

Section of Well near New Castle.

	<i>Feet.</i>
1. Soil	2
2. Yellow clay	8
3. Gravel	15
4. Quicksand	25
5. Blue clay	31
6. Gravel	2
7. Hardpan	7
8. Coarse gravel with water.....	3+

The surface clays of the county are either yellow, where thoroughly oxidized, or gray where they have not been so affected; beneath the surface they are of a bluish or gray color. They are used for manufacturing purposes only at Newcastle and Grant City. At the former place from one to three feet are used, without stripping, for the making of ordinary red brick and drain tile. At Grant City, after removing three or four inches of black soil, the underlying clay is used to a depth of three to six feet in making drain tile.

In Rush County the drift has an average thickness of about 100 feet, and is composed mainly of gray, yellow and blue clays, though the lower part is frequently sand or gravel. Dr. M. N. Elrod, in his report on the Geology of Rush County,* has given an excellent account of these clays, as follows: "From top to bottom the surface wells of the county show: (a) Soil one to two feet; (b) yellow or red clay, 3 to 10 feet; (c) blue plastic clay or gray hardpan, with occasional buried timber, muck or peat, 10 to 40 feet; (d) sand, quicksand or gravel, three or more feet. In some of the wells one or more of the generally found strata are wanting; either they were never formed, or, by the action of local causes, they have been removed, or altered and blended, until it is impossible to identify them as the equivalent of any particular stratum;

* Thirteenth Rep. Ind. Geol. Surv., 103, et. seq.

but, however altered and changed, the order of succession remains the same in the Rush County drift.

"The blue plastic clay, boulder clay, glacial clay or hardpan (c) is a very generally diffused member of the drift, occurring universally, except in the valleys south of Rushville, where the rivers and creeks reach down to or near the bed rock. In physical appearance it is a blue or lead-colored clay, where protected from atmospheric change; where exposed, of a lighter shade. It usually occurs in compact beds, ranging from a soft, laminated, plastic, puttylike mass to a dry, impervious hardpan, that can only be excavated with a pick. That these differences in consistency are largely due to moisture may be shown by subjecting different specimens to the same drying process. Chemically, it is an alumina silicate, mixed with fine, impalpable sand and salts of iron; its color is due to the latter.

"The yellow or orange-colored clay (b) is found everywhere overlying the blue clay, except in the valleys and upland gravel ridges. Over the east side of the county and in the vicinity of New Salem and Richland it is so intimately associated with the top soil that it is not possible to separate them. Near the Fayette County line the color is a reddish orange, and especially so in parts of Washington Township. In the uplands on the east and north sides of the county it is comparatively free from gravel. In structure it is a heterogeneous, friable clay, much more pervious to water than the blue clay, and yet so tenacious as to be improved by tiling. The percentage of lime is quite large, as indicated by a vigorous growth of sugar maple. The calcareous matter and very fine sand incorporated with the orange clay in parts of Richland, Noble, Union and Washington townships give it many of the physical characters of loess. Ten feet will cover its average thickness in Anderson Township; that gradually grows heavier on the north, until it will measure 30 feet or more. Near the southeast corner of the county the yellow clay is very thin, and over the line in Franklin county it fails as a factor of the drift period, and leaves the blue clay exposed as the surface clay."

Any of the yellow or blue clays of Rush County, when free from gravel, can be readily molded and burned into brick or tile. At the present time two yards are in operation at Rushville.*

* See statistical table at end of paper.

These use from four to six feet of soil and underlying yellow clay without stripping.

At Homer Arbuckle & Son operate a large factory for the making of drain tile and hollow building block. A surface clay is used to a depth of three and a half feet, after removing three or four inches of black soil. The value of the output in 1904 was \$10,000.

In Decatur County the thickness of the drift is, as a rule, less than 50 feet, and at many places wells enter rock at 20 feet or less. One of the thickest deposits occurs north of Adams, where, on the Robinson farm, a gas well bore penetrated the following strata:

Section Through Drift of Bore North of Adams.

	<i>Feet.</i>
1. Soil	2
2. Yellow clay	17
3. Sand	4
4. Blue plastic clay.....	52
5. Gravel and sand.....	15
6. Yellow hardpan	5
7. Oily blue hardpan.....	16
8. Coarse gravel	15
9. Hard blue hardpan	20

A typical section of the various strata shown in the ordinary surface well of Decatur County is given by Dr. Elrod in his report on the geology of the county, as follows:*

Section in Well near Hartsville.

	<i>Feet.</i>
1. Soil, mixed with very little gravel.....	2
2. Yellow clay with gravel and small angular boulders.....	15
3. Black carbonaceous soil with timber.....	2
4. Blue boulder clay, mixed with gravel near the top, and very tenacious and plastic at the bottom.....	5
5. Corniferous limestone	4

"Of course, it is not to be expected that every well in the county that even reaches down to the bed rock will show all the four strata seen in this well, as some one or more may be wanting, but the order in which they occur is never changed; blue boulder clay never overlies yellow clay.

"The blue boulder clay is the most generally present of any member of the drift series, and covers the bed rocks of the whole county, except where it has been removed by the action of erosion.

*Twelfth Ann. Rep. Ind. Dept. Geol., 1882, 140.

This clay, weathered and altered in appearance by exposure to atmospheric influences, is the surface soil of the 'flat woods.' Where protected by the yellow clay, its color is blue or drab; where exposed, weathered to a grayish white. The difference in color is due to the action of the oxygen of the air on one of its constituents, the oxide of iron. In the 'flat woods' the top is free from gravel. When covered with yellow clay, and the top has been disturbed, the color is a little lighter blue, and the proportion of gravel increased near the line of junction, but the true strata may be readily distinguished, the one from the other. The consistency is very different; the blue clay is a uniform, sticky, plastic, wet mass, nearly impervious to water, the equivalent of the 'tile' of the English geologist, and when dry a veritable 'hardpan.' The yellow clay is easily excavated, wet or dry, and, freed from moisture, is very friable."

The weathered white clay of the "flat woods" district of Decatur County is a first-class brick or tile clay. The upper or yellow surface clays, where sufficiently free from gravel, are also extensively used. Five or six small yards are at the present time utilizing these clays* for such products. At Greensburg from 18 inches to two feet of yellow clay are used without stripping, lime pebbles preventing its use to greater depth. At Spring Hill, after stripping six to eight inches of black, sandy soil, the underlying yellow clay is used to a depth of three to four feet in making drain tile.

In Ripley County the drift is seldom over 50 feet in thickness, and averages much less, the thickest beds occurring in the northern part of the county. At Milan, near the eastern edge, on the B. & O. S.-W. Railway, a surface well, 54 feet in depth, showed the constituents of the drift to be as follows:

Section of Well on Railway Property at Milan.

	<i>Feet.</i>
1. Light colored clay and soil.....	11
2. Yellow clay with flint gravel and fossil corals.....	12
3. Blue glacial clay	12
4. Coarse yellow sand.....	8
5. Blue clay containing roots and limbs of trees.....	8

This well is probably sunk in an old pre-glacial channel, as limestone occurs close to the surface but a short distance away.

The extensive "flats" of the northern and northwestern por-

*See statistical table at end of paper.

tions of the county are composed mainly of a light-colored surface clay, with a trace of sand, and terminate downwards in clay of various shades of color. At an old tile and brick works at Sunman the following section was obtained by W. W. Borden and given in his report on the county:*

Section at Clay Pit at Sunman.

	<i>Feet.</i>
1. Light colored clay with a trace of iron, used for brick...	3
2. Light blue to deep blue clay, used for tile.....	4
3. Ocherous clay with shades of blue.....	3
4. Blue and yellow sand with water.....	2+

"The clays throughout the county have the same general appearance, with a trace of black sand, which is to be seen in streaks and in the washings on the roadside. It readily adheres to the magnet when dry."

At the present time brick are made in the county only at Batesville.

In Jefferson County the drift on the uplands, especially in the "flats," runs 10 to 35 feet in thickness, and consists mainly of a compact clay, the upper portion being gray to white in color, nearly free from pebbles and having an average thickness of about five feet. At Madison several wells on a terrace, 90 to 100 feet above the river, have reached a depth of 120 feet without entering rock.

At several places in the county there is exposed between the Jeffersonville and Niagara limestones a partially disintegrated clay shale, which can be burned into a variety of clay wares. The most available exposure of these is southeast of Dupont, at the crossing of the J., M. & I. Railway and Big Creek. Here it occurs four to six feet thick between two layers of limestone.

In 1895 several days were spent in investigating the clays of Jefferson County, and a large number of samples from different parts of the county were also submitted for examination. Of the samples submitted but two or three were deemed of commercial importance. One of these was a partially decomposed shale, found on the southwest quarter of section 20 (3 N., 9 E.). It was soft, very plastic, free from grit and of exceedingly fine texture. A visit to the locality showed the following section outcropping on the banks of a small creek:

* Seventh Ann. Rep. Ind. Geol. Surv., 1875, 196.
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Section on Creek Northwest of Hanover.

	<i>Feet.</i>
1. Soil and yellow clay.....	3
2. New Albany shale	1
3. Gray clay	2
4. Gray shale	2
5. Dark limestone, undetermined.	

The clay No. 3 is evidently derived from the weathered portion of the underlying shale. If both it and the shale, No. 4, were gotten out in the autumn and allowed to weather for six months it would become soft and plastic and could be burned into excellent stoneware and sewer pipe.

Another deposit of some value was a surface clay from the farm of C. H. George, in section 17 (4 N., 10 E.), near the station of Wirt, on the J., M. & I., and not over an eighth of a mile from the railway. It is part of a yellowish surface stratum of fine texture and free from grit and gravel. A section at the point of occurrence showed as follows:

Section near Wirt.

	<i>Feet.</i>	<i>Inches.</i>
1. Surface	2	0
2. Red silicious clay	15	0
3. Coarse grayish limestone.....	1	0
4. Chert in angular fragments.....	0	6
5. Limestone	2+	0

The red clay, No. 2, will make excellent ordinary or pressed-front brick; also roofing and drain tile.

On the land of the same party, in section 8 (4 N., 10 E.), is a grayish or whitish clay, near the surface, which will make excellent drain tile or ordinary brick. This underlies the surface soil over a large area in the neighborhood of Wirt station.

W. A. Law, from near Deputy, sent in to this office samples of shale of fair quality for pressed front or ordinary brick. He states that the bed from which samples were secured runs four and a half feet thick over an 80-acre tract within three miles of the J., M. & I. Railway.

Good tile clay occurs in abundance near North Madison and in the strip of flat lands, three to four miles in width, crossing the county from northeast to southwest, between Dupont and Hanover. Two brickyards at West Madison use from three to eight feet of "river bank clay," and such material abounds in the terraces and lowlands along the Ohio.

V. COUNTIES OF THE LOWER SILURIAN AREA.

The Lower Silurian or Ordovician rocks occur, as already noted,* only over parts or all of nine counties in the southeastern part of the State. Of these the clays of Ripley and Jefferson have been mentioned, since the rocks of the greater part of their surfaces belong to the Upper Silurian Period. The remaining counties will be grouped and their surface clay deposits briefly discussed.

WAYNE, FAYETTE, UNION, FRANKLIN, DEARBORN, OHIO AND SWITZERLAND COUNTIES.

These counties comprise an area of 1,800 square miles, over which, with the exception of a portion of northern Wayne and western Fayette, the shales and limestones of the Lower Silurian Period are found. The greater part of the northern half of the area lies within the limits of the Wisconsin glacial deposits—the southern boundary line of that glacial invasion passing in a northwest-southeast direction through Fayette and Franklin counties into Ohio. Over the portion of the area covered by that glacier the drift is much thicker than over the southern part, where only the drift of the earlier Illinoian glacier was deposited. The only clays of any value found in the area are the drift clays deposited where they now lie by one or the other of the glaciers mentioned, or the alluvial clays along the lowlands or second bottoms of the streams, the shales of the Lower Silurian rocks being everywhere too calcareous in nature for clay products.

The Niagara limestone occurs beneath the drift along the northern and eastern edges of Wayne County, but the rocks of the greater part of its area belong to the Ordovician Period. With the exception of the surface rocks, they are covered with 150 to 200 feet of drift material. Extensive gravel plains occur in the western and northern portions of the county, and also along Green and Noland forks of the Whitewater. In the eastern part of the county and on the uplands between these gravel plains the drift usually consists of yellow or blue clay. An average section through the upper portion of the drift in this region would show the constituents to be arranged about as follows:

* See p. 43.

Section Through Drift in Wayne County.

	<i>Feet.</i>
1. Soil	2
2. Yellow clay	15
3. Sand and gravel	10
4. Blue clay and gravel	18
5. Hardpan	2
6. Sand and gravel	20
7. Blue clay and gravel	15

There are usually two or three layers of impervious, compact blue clays, oftentimes mixed with well-rounded boulders from the size of a small gravel to six inches or more in diameter.

Brick and drain tile are made from the surface clays at Richmond and East Germantown. At the former place, after stripping six to eight inches of top soil, the underlying yellow clay, to the depth of 30 inches, is used for drain tile, while at the principal brick yard from eight inches to four feet of surface clay is used without stripping. At East Germantown "from one to four and a half feet of hickory pocket clay, mostly found where clumps of hickory trees grow," is used for drain tile and hollow block, after stripping 6 to 14 inches of sod and soil.

Prof. E. T. Cox, in his report on the geology of Wayne County,* makes special mention of the following clays:

"On Levi Jessup's land, about one mile northeast of Richmond, there is a fine bed of potters' clay exposed in the east bank of the Middle Fork of Whitewater. The following shows the character of the exposure:

Section at Clay Pit, One Mile Northeast of Richmond.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil	2	0
2. Sand with gravel and small boulders.....	16	0
3. Yellow plastic clay, burns reddish.....	0	10
4. Blue plastic clay	8	6
5. Gravel, sand and small boulders.....	25	0
6. Bed of creek	0	0

"The blue plastic clay, No. 4, when damp, is soft and cuts like cheese; has an unctuous feel, and a little grit when tested with the teeth. It burns cream color and lies in thin laminæ of about half an inch thick, and dips three degrees south of east.

"In a pottery at Richmond, in which greenhouse flowerpots

*Tenth Ann. Rep. Ind. Geol. Surv., 1878, 217.

and saucers are made, this clay is used, and the ware has a very agreeable cream color. A great variety of ornamental hanging baskets and vases are also manufactured from the clay. About six tons of this clay are used in a week, from which about 30,000 flowerpots are made in the same time. The following analyses show the composition of these clays:

Analyses of Clays from Jessup Land, Northeast of Richmond.

	<i>Yellow Clay No. 3.</i>	<i>Blue Plastic Clay No. 4.</i>
Loss at red heat.....	9.50	12.60
Silicic acid	44.50	45.30
Ferric oxide	16.00	13.20
Alumina	6.80	9.60
Calcium carbonate	12.30	12.90
Magnesium carbonate .....	....	2.98
Sulphuric anhydride .....	.20	.63
Chloride of alkalies.....	3.80	2.30
Loss and undetermined.....	6.90	.49

"The yellow clay appears to contain too much calcium carbonate, ferric oxide and alkalies to stand a very high heat."

An analysis of a mixture of the two clays, Nos. 3 and 4 of the section, just as they occur was made by Dr. Lyons, and the chemical composition found to be:

Analysis of Clay from Jessup Land, near Richmond.

Silica (SiO ₂)	67.76
Titanium (TiO ₂) .....	.89
Alumina (Al ₂ O ₃)	13.69
Water, combined	7.10
<hr/>	
Clay base and sand.....	89.44
Ferric oxide (Fe ₂ O ₃).....	5.09
Ferrous oxide (FeO).....	.46
Lime (CaO) .....	.94
Magnesia (MgO) .....	.51
Soda (Na ₂ O) .....	.51
Potash (K ₂ O)	3.26
<hr/>	
Fluxes	10.77
<hr/>	
Total	100.21

The analysis proves the clay well fitted chemically for making flower pots and kindred products, dry pressed front and ordinary

brick. It will not make sewer pipe and other vitrified wares, as the percentage of fluxes, notably potassium, is too high.

In Fayette County rock is seldom encountered on the uplands at less than 50 feet, and in most places over the northern two-thirds of the county the drift runs 100 feet or more in thickness. "On either side of the Whitewater, in the south part of the county, there is a small district in which the newer or Wisconsin Drift is absent, and a coating of white clay or silt several feet in thickness covers the till of the earlier or Illinoian invasion. Here, as has been noted in other counties of Indiana, the older drift sheet is much more highly oxidized and harder than the newer sheet. In the newer drift wells may be easily spaded or bored, while in the older drift a pick or drill must often be used."*

The average surface well in the county will disclose about the following sequence and thickness of the drift strata:

Average Section of Wells in Fayette County.

	<i>Feet.</i>
1. Soil, black	2
2. Yellow clay	9
3. Blue plastic clay	30
4. Sand or gravel	3+

"The yellow clay stratum is the most generally distributed of all the drift strata in the county, the blue clay coming next, and everywhere present except in the creek and river valleys. Nowhere did I find it absent and the blue clay exposed on the surface. This fact has an important bearing on the agricultural interests of the county, as the yellow clay is always fertile and the blue clay only imperfectly so. As a surface clay the latter is known as the white or 'crawfish' lands.

"The blue clay or hardpan is the soft or indurated material struck in digging beneath the yellow clay. Generally it is a hardpan clay, dry and very difficult to dig, as it cannot be penetrated with a spade, and the pick will detach no more than the width of the blade. When kept constantly moist by water from above it may become softened and assume the character of an unctuous clay."†

At Connersville A. Fries & Son are making common brick and

* Leverett. "Wells of Southern Indiana," in Water Supply and Irrigation Papers, No. 16, p. 35.

† M. N. Elrod. Geol. of Fayette Co. In 14th Ann. Rep. Ind. Geol. Surv., 1884, 46.

drain tile from "a lake deposit (alluvial clay), eight feet thick, free from sand or gravel," while C. P. Ariens uses four feet of yellow surface clay for common brick.*

On the farm of G. C. Parsons, in the southwestern part of Fayette County, occur several deposits of clay worthy of note. From a report on these made by Warren Riddell, of Xenia, Ohio, I quote as follows: "At one point on the farm of 492 acres there is a light grayish clay, an analysis of which resulted as follows:

Analysis of Surface Clay from Parsons Farm.

Lime (CaO_2)	18.50
Silica (SiO_2)	56.40
Alumina (Al_2O_3)	16.02
Ferric oxide (Fe_2O_3)	6.05
Magnesia (MgO)	trace
Sulphuric anhydride (SO_3) .....	.63
Alkalies	1.15
Loss on ignition	1.00

"This clay is evidently a very fine deposit of cement material when combined with the proper stone. It contains scarcely any grit and is free from many of the injurious impurities usually present in such clays, and would indicate, when combined and ground with the proper rock, a cement answering all the requirements of the best hydraulic slow setting cements.

"It was found that this clay was a formation of successive layers, and extends for the full width of a low swale or basin, 40 to 60 feet wide. There is an average of from one and a half to two feet stripping on top, and it is so located as to be easily and conveniently handled. A large amount of what is evidently the same material was found at several other points.

"One of the most interesting deposits on the farm is at the extreme northeastern corner. Here, along a deep gully or ravine, is deposited a rich brown clay, partaking of the qualities of soapstone, and running in layers or seams. A hole was dug to the depth of ten feet. Each layer taken out seemed richer than the last. A sample of this clay was sliced down in very thin layers and dried without any indications of a check, being absolutely without grit. The dried sample is susceptible of a very fine polish. When burned it varies from a pale pink to deep maroon in color,

* See statistical table at end of paper.

owing to the amount of heat and the time it is burned. I am quite sure of the commercial value of this clay, both as a terra cotta and a face brick clay, and possibly as a vitrifier, samples being shown me perfectly vitrified. This clay runs from 16 to 60 feet deep, and has a cover of from two to three feet on an average above it, which would have to be removed."

Just east of the Parsons land, on the farm of W. F. Limpus, section 28 (13 N., 12 E.), one and a half miles west of Alpine, a station on the Big Four Railway, occurs another thick deposit of a somewhat similar silty or marly clay. The top or light colored stratum runs about 30 feet in thickness, and has a total exposure on the north side, with little or no stripping. The darker blue, almost black stratum, lying beneath, continues down to the creek bed, a distance of about 40 feet. This clay will doubtless be found suitable for the making of terra cotta lumber and other fire-proof products. On account of the high percentage of lime present, it can not be made into vitrified material. It can also be used as a polishing powder and for making ordinary brick, but the brick will be of a light color, due to the large amount of lime.

In Union County the drift is sufficient in thickness to give a smooth surface to what would otherwise be a hilly district. It runs from 20 to 40 feet on the uplands and as high as 200 feet in the lower valleys. In the eastern part of the county the yellow clay runs 12 to 15 and the blue 40 to 80 feet in thickness. The upper portion of the yellow clay is free from pebbles and suitable for brick and drain tile in many localities, but there is at present not a clay-working factory in the county.

Only a small portion of Franklin County lies within the limits of the Wisconsin glacial invasion, the line of its southern boundary passing across the northeastern and touching the northwestern corners of the county. The older sheet of drift, covering the greater part of the county, has for its surface a deposit of white clay several feet in thickness. This represents the underlying blue clay found in the counties to the westward. On the higher uplands surface rock is often struck at a depth of 10 feet or less, but in the valleys the drift reaches a thickness of 50 feet. The older drift is everywhere harder and more deeply oxidized than the newer.

Clay of good quality for the making of brick or tile occurs in all parts of the county. On the uplands the fine-grained, grayish-white clay, above mentioned, is suitable, while on the lowlands of the Whitewater the alluvial clays will make as good, if not better, wares.

But two factories are at present operating in the county. The larger of these, that of A. Fries & Sons, at Brookville, uses from 5 to 15 feet of very plastic alluvial clay from the Whitewater Valley in making building brick, the output being 660,000 in 1904.

In Dearborn County the drift is wholly that of the earlier Illinoian glacial sheet. On the higher parts of the uplands the drift runs but 10 to 20 feet in thickness, and is covered with a deposit of white clay, nearly free from pebbles, which has an average thickness of about five feet. In the valleys from 75 to 100 feet of drift is common.

Suitable material for brick and tile-making occurs in various parts of the county. The grayish-white clay of the uplands is generally free enough from impurities for the purpose, while along the terraces and lowlands of the Ohio there is abundance of material. At the present time these clays are utilized only at Lawrenceburg and Aurora,* brick being made on a large scale at both places. At Lawrenceburg "Ohio River bottom clay to a depth of 25 feet" is used, the output in 1904 being 3,250,000 brick. At Aurora brick to the number of 1,700,000 were made from a "sandy, loamy clay, 20 feet deep."

In Ohio County the available clays are very similar to those of Dearborn, the white drift clays occurring over the more level uplands and the alluvial deposits in the terraces and lowlands along the river. At Rising Sun brick were formerly made from clay taken from a river terrace. The upper part contained too little sand, but by mixing with a lower stratum clay of good brick-making composition was obtained. At the present time there is not a clay-working industry in the county.

In Switzerland County the same conditions exist, the unstratified, grayish-white clay, three to five feet thick, being found over the more level uplands, and good alluvial clay along the terraces

*See statistical table at end of paper.

and lowlands. Brick were made for a long time from the terrace clays at Vevay, but neither brick nor tile factory is at present operated in the county. Mr. R. B. Warder, in his report on the geology of the county,* states that "red pottery ware was made at Vevay 50 years ago," and also that "where the river terrace slopes toward the hill, as at Vevay, a stiff blue clay sometimes occurs which may be derived from the native marl washed from the hillsides. This, mixed with sand, is recommended for setting grates. It is said to be better for steamboat furnaces than genuine fire-clay."

* Geol. Surv. of Ind., 1872, 418.

VI. COUNTIES OF THE DEEP DRIFT COVERED AREA.

The list of counties comprising this area was given on page 41 of Section II. In but few localities in the entire area is any surface rock exposed to view, the drift being too thick for the streams to have reached its bottom since the close of the glacial epoch. As a consequence, the drift clays and their secondary deposits, the alluvial and marly clays, form the only commercially available clay working materials of the region.

BENTON COUNTY.

Benton County comprises an area of 414 square miles of the most fertile portion of northwestern Indiana. It lies on the western border of the State and is the third county south from Lake Michigan. Its entire surface is a gently rolling prairie broken only by three prominent morainic ridges which run in an easterly and westerly direction across its area. Standing upon one of these ridges near the center of the county, one can behold the undulating prairie spreading away in all directions like the billows of the ocean. Timbered groves—*island like*—dot here and there its surface, and well built farmhouses with surrounding orchards are seen on every side. No finer body of farming land exists in the Mississippi Valley than these rolling plains of Benton County.

The soil is everywhere a rich black loam, composed of the remains of plants which have decayed under water, and of silt which has been mixed with them by slow decomposition. For, after the recession of the great ice sheet which covered the underlying rocks with a thick deposit of boulder clay, all these prairies were covered with shallow lakes, which by natural causes were gradually drained. In the first settlement of the county many of the prairies were too wet for cultivation, and a number of marshes which had not yet reached the stage of "wet prairies" were scattered at intervals within its bounds. To properly drain these wet regions was for years the chief problem of the land owners. This has been accomplished by the construction of a great system of surface ditches which ramify throughout every portion of the county. These have necessitated the using of an

immense quantity of drain tile. The manufacture of this tile has been the chief, and up to 1904, practically the only clay industry in the county; but the demand has recently fallen off to such an extent that several of the larger factories have been abandoned.

The clays of Benton County are all of them of glacial origin. They lie immediately beneath the black prairie loam, and vary in known thickness from five to 130 feet. When first deposited by the melting ice, these clays were a uniform blue in color. In the course of time, however, the upper portions of the clay beds have been percolated by waters containing humic acids and other substances from the decaying vegetation above. These have changed the ferrous or lower oxide of iron to the ferric or higher oxide. As a result, the upper five to 20 feet or more of the clay is now a brownish yellow. There is often a sharp line of division between the yellow, weathered portion and the blue or unweathered part of the clay. The latter is usually the more plastic and the better in quality.

The best deposit of clay in Benton County, so far as known, is the one at Earl Park, on the Chicago Division of the Big Four Railway, now worked by J. J. Holtam. A section obtained at the pit showed as follows:

Section of Clay Pit at Earl Park.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil, stripped for working.....	0	8
2. Coarse grained yellow clay, with many small pebbles	4	0
3. Fine grained drab clay.....	8	0
4. Blue clay, marly, fine-grained.....	38	0
5. Limestone	?	0

No. 2 of this section contains little lime, except what is in the pebbles. It is more refractory than the clays of the lower strata, but the lime and other pebbles must be removed or crushed, else they will spoil all wares produced from it.

The clay of stratum No. 3 is very similar to that of No. 4, except in color. Its lighter hue is due to leaching waters. The sediment of which the two strata are composed was probably deposited in still water by a stream from the retreating ice sheet. They contain an occasional drift pebble, but no large number of

small limestone pebbles, as does the upper stratum. Both are very fine grained, effervesce freely with acids, and are to be classed as marly clays. They probably contain about eight per cent. of carbonate of lime and magnesia in addition to the other fluxes. For this reason vitrified products of high quality can not be made from them. Mixed with the upper clay, No. 2, they will withstand more heat. From them alone can be made, however, good pressed front brick, terra cotta lumber, drain tile and ordinary building brick.

At the present time only drain tile and stiff mud ordinary brick are made by Mr. Holtam, the former from a mixture of all the clays, the latter from the two upper strata. A Potts disintegrator is used to separate the pebbles and a J. D. Fate stiff mud brick and tile machine for making the wares. For drying the latter, four floors are used, each 60x90 feet, heated by steam pipes; and for burning, four down-draft kilns, each of which hold 40,000 brick.*

The following is the daily capacity of the different sizes of tile made on a Fate brick and tile machine at the Earl Park Works, and the price of tile at that place in 1904. Fifteen tile of any size equal one rod in length:

<i>Size.</i>	<i>Daily Capacity.</i>	<i>Price per 1,000.</i>
4 inch.....	10,000	\$13 50
5 inch.....	7,000	19 00
6 inch.....	5,000	28 00
7 inch.....	3,500	34 00
8 inch.....	3,000	40 00
10 inch.....	2,500	60 00
12 inch.....	2,000	80 00
14 inch.....	1,200	115 00

At Lochiel, on the C. & E. I. Railway, drain tile were made for a number of years by the Lochiel Tile Company. The material used was a stiff, dark colored drift clay, which contains numerous small pebbles of lime. It is rather coarse grained and resembles the upper stratum at Earl Park in containing too small an amount of disseminated lime to effervesce with acids. Six inches of soil were stripped and the clay used only to a depth of four feet. It was hauled in carts to the plant and passed through a crusher, and then through an Adrian brick and tile machine.

* See statistical table at end of paper.

Experiments in making pressed brick were tried, but the brick were too brittle and the clay in general too coarse. Some hollow brick of good quality for foundation work have been made at this place. This company at one time produced the second largest output of tile of any in the county, but the demand gradually decreased and the factory finally shut down. If the clay were properly crushed, a good grade of tile could be made at Lochiel, but the qualities of the clay are not of the best for the making of other wares.

For a number of years both brick and drain tile were made at Fowler, the county seat. The material used was a rather coarse grained, hard-pan or "drift clay" very similar to that at Lochiel, but containing a much smaller number of lime pebbles. Five feet of clay were utilized after six inches of soil had been stripped. This factory has not been operated since 1900. Ample dry sheds and three round down-draft kilns of standard size are yet in place.

At Oxford John Lawson made drain tile on a small scale for 20 years, but closed his factory in 1903. On his tile yard was a flowing well 50 feet deep, which pierced the gravel beneath the blue clay. The clay for tile was gotten from low ground. Eight inches of soil were stripped and 16 inches of a blackish sedimentary clay wholly free from lime pebbles were first taken out. This was mixed with three feet of underlying yellowish clay, then passed through a crusher and made into tile on a Hoosier tile machine.

At Otterbein tile have been made by Wm. Lawson since 1891. After stripping 10 to 12 inches of black soil, a yellow surface clay three feet in thickness is used. This is passed through a Wallace crusher and then through a Little Wonder tile machine. The output in 1904 was valued at \$5,100.

Other tile factories at Templeton, Wadena and Boswell have been abandoned in recent years. The reason for this abandonment, as well as that of the decreased output of all other factories are two, viz., the gradually decreasing amount of lands needing drainage, and the selling in Benton County of tile from Summitville, Montezuma and other points in the natural gas and coal fields, cheaper than they could be there manufactured at a living profit.

On the whole, it may be said that the clay resources of Benton County are inferior in value to those of the counties in the coal bearing area of Indiana, or of some of the counties adjacent to Lake Michigan. But what the county lacks in clays it far more than offsets in the richness and productiveness of its prairie soils.

NEWTON COUNTY.

Newton County comprises 400 square miles of northwestern Indiana, lying adjacent to the Illinois line, north of Benton and west of Jasper counties. The Kankakee River forms its northern boundary and drains the northern half of its area. The Iroquois River flows across the southern half of the county from east to west. It forms the northern boundary of that magnificent prairie region which embraces the southern third of Newton and all of Benton counties. North of the Iroquois are also some fine prairies which extend to the southern border of McClellan and Colfax townships.

With the exception of about 25,000 acres, formerly comprising Beaver Lake, the surface of the four northern townships of Newton County is covered with loose sand. Up to the present, this sandy area has been deemed comparatively worthless for agricultural purposes, but the time will soon come when, by proper cultivation, it will be made to yield handsome returns in small fruits and certain vegetables. The area covered by Beaver Lake was long since drained into the Kankakee and now comprises one of the most productive regions of the county.

The clays of Newton County are all of them drift clays or marly clays. They were deposited either by the melting ice or by the still water of the numerous shallow lakes which for centuries immediately following the glacial period covered the greater portion of the county. In many places they cover the uppermost rocks to a depth of 120 to 140 feet, and in but a few known places are they less than 10 feet in thickness. The northern third of the county was not visited since it is so covered with sand and lacking in railway facilities for transporting clay products. The fine grained blue clay common to the region will doubtless be found to underlie all of this sandy area to a great depth.

In the vicinity of Kentland there are no clay factories, and no

openings where the strata of underlying clay are exposed. The record of the well in the public square shows the blue glacial clay to be 146 feet in thickness. At Kent's warehouse it was 80 feet, and on Kent's farm, two miles southwest of Kentland, section 29 (27 N., 9 W.), 50 feet in thickness.

A brick yard was for some time located on the north side of the Iroquois River, where the road running north from Kentland crosses that stream, southwest quarter section 34 (28 N., 9 W.). The clay is yet exposed in a cut by the roadside to a depth of five feet. It is a fine grained, reddish, loamy clay, free from pebbles and lime, and will withstand much heat when burned. It should make excellent ordinary brick, but is not suited for drain tile on account of the large amount of free silica which it contains.

At Morocco, in the south half of section 21 (29 N., 9 W.), Darroch Bros. operated a brick and tile yard for a number of years. The firm had their plant very well fitted with machinery, but were unfortunate in the selection of their clay. Seven inches of soil were stripped and three feet of brownish drift clay utilized. It was very full of lime pebbles, and for that reason the brick and tile were of poor quality. One hundred yards north of their plant the blue clay comes within five feet of the surface and will make a much better tile, but they will be a yellowish white in color. Two well sections at Morocco show this blue clay to be 113 and 120 feet in thickness, very fine grained and very plastic.

A much better clay for tile and brick making occurs at Beaver City, and has been worked since 1893. The section at the pit is as follows:

Section at Clay Pit at Beaver City.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil, stripped	0	6
2. Yellowish sandy clay	3	6
3. Tough bluish clay	4	6

Wares made from the above yellowish clay air crack in drying, especially if exposed to the wind. When the yellow clay is mixed with the blue, this is prevented. The blue clay has been proven by a bore to be 140 feet in thickness. But little trouble is had with lime pebbles, as comparatively few are present. The clay

is thoroughly moistened, pugged and crushed before entering the machine. The mixture burns red, and the owner claims that red tile sell much better than white, as they stand freezing better.

At Mt. Ayr, on the La Crosse Branch of the C. & E. I. Railway, a grayish blue clay comes close to the surface in a marshy field in the eastern outskirts of the town, and is worked into brick and tile by Stucker & Covert. It is fine grained and tough, but contains occasional botryoidal masses of pure amorphous carbonate of lime the size of a marble or smaller. No true pebbles of lime are found in the clay and a similar occurrence of amorphous lime was noted nowhere else in northwestern Indiana. The clay itself possesses scarcely enough lime in its composition to cause an effervescence with acids, and burns a bright red. Four to six feet of it are used, the deeper portions burning to wares of a lighter color. If the lime above mentioned was absent, the clay would be of most excellent quality for drain tile, flue linings and fire-proofing. The plant has not been in operation for two years, but will start again in the spring of 1905.

The largest and best equipped clay factories in Newton County and among the best in northern Indiana, are those of the Brook Terra Cotta Tile and Brick Co., at Brook, a station on the C. & E. I. Railway. Two factories are in operation, one on the south and the other on the north side of the town. The south factory was started about 15 years ago by J. H. Haynes, President and manager of the company. In 1901 the business had so grown that a company was organized under the title given, and a new plant built on the north side of the town, where there was more room and a larger deposit of clay. At the time of my visit a section at their pit just southeast of the old factory, northwest quarter of section 20 (28 N., 8 W.), showed as follows:

Section at Clay Pit of South Brick and Tile Factory at Brook.

	<i>Fet.</i>
1. Black soil	1
2. Yellowish loamy clay	2
3. Grayish or drab marly clay.....	5
4. Tough blue marly clay.....	4
5. Gravel and sand	?

The entire deposit was evidently laid down in still water instead of being dropped by melting ice. As a consequence but

little trouble is experienced with lime pebbles. From a portion of the soil and the loamy clay, No. 2, ordinary red brick and drain tile were made for a number of years. In 1895 the company began to utilize the upper marly clay, No. 3, in making terra cotta lumber for the Chicago market. This clay is a silt, the lower part of the stratum being in thin layers with a coating of sand between them. An incomplete analysis shows that it contains about 10 per cent. of magnesium and lime carbonates.

From the blue clay, No. 4 of the section, flue linings, solid fire-proofing, furring brick and foundation brick are made. This clay, as well as No. 3, burns to a cream color on account of the large percentage of lime which it contains.

The clay used at the new factory is very similar to that at the old, but the deposit covers a much larger area.

For nearly 20 years, and until 1900, the Goodland Tile Company made drain tile, hollow and ordinary brick at Goodland, in the southeast corner of Newton County. The clay which was mostly used is peculiar for this region of the State in that it is a pinkish red in color. It resembles closely the clay of the same color found near Freedom, Owen County,* which is quite largely used in the making of encaustic tile and terra cotta. Both are very fine grained, free from grit and pebbles, and exceedingly tough and plastic. The clay at Goodland effervesces rather freely with muriatic acid, showing that it contains several per cent. of lime carbonate, while on that from Owen County acid has no effect. The latter is, therefore, much the more refractory.

A section of the old clay pit at Goodland shows as follows:

Section of Clay Pit at Goodland.

	<i>Feet.</i>
1. Soil	1
2. Grayish pebbly hardpan or drift clay.....	3
3. Pink clay	6
4. Blue clay merging into shale.....	7

The pink clay covers a large area southeast of Goodland, southwest quarter section 25 (27 N., 8 W.), on the land of W. J. Stewart. Burned by itself, it produces ware of a dark red color. Mixed with the overlying grayish clay, it burns brown. Drain tile made from it are very hard and ring when struck, as though

*See under Clays of Owen County, p. 221.

composed of iron. On account of its tough, plastic condition it is apt to twist and shrink under the influence of great heat. It must be thoroughly moistened in a pug mill, as it is too tough to work dry. When properly tempered or weathered it does not air crack in drying. It possesses all the properties of an excellent modeling clay, and is of too high a grade to be used only for brick and drain tile.

From what has been stated it will be seen that the clays of Newton County are more varied in character and of better average grade than those of Benton. Good deposits of marly clay, suitable for terra cotta lumber, doubtless occur along the Iroquois River, east and west of Brook. Three railways pass through the county and its proximity to the coal fields of both Indiana and Illinois renders cheap fuel a certainty. There is no reason why additional large clay industries should not start up and flourish, especially at Goodland and Brook.

LAKE AND PORTER COUNTIES.

These two counties comprise an area of 920 square miles in the extreme northwestern corner of the State. They lie north of the Kankakee River, south of Lake Michigan, and east of Cook, Will and Kankakee counties, Illinois. Their area embraces three distinct belts or regions, each with well marked surface characteristics. These, briefly described, are as follows:

1. *The Calumet or Northern Region*, so called because the Calumet River flows east and west through its full width, comprises approximately 250 square miles, 162 of which are in Lake County and 88 in Porter. On the western border of Lake this belt is 15 miles wide, but it narrows as it passes to the northeast until it is but eight miles in width, where it passes into Porter County, and but seven miles where it leaves that county at the northeastern corner. This region is almost wholly sand covered. Along the northern edge the sand is mainly in high dunes or hills, whose elevations and positions are continuously being changed by the wind; while over the southern portion it is thrown up to a height of six to 15 feet above the surrounding surface. In many places these deposits are spread out over an area a half a mile or more wide, in the form of small parallel ridges with

numerous depressions or sags intervening. This region owes its surface configuration partly to a former extension of Lake Michigan southward, and partly to the action of the wind on the sand thrown up by the present lake.

2. *The Morainic or Middle Region.*—Four hundred and eighty-five square miles of the surface of the two counties are comprised in this belt, about 250 of which lie in Lake, and the remainder in Porter. The higher altitude and more rugged surface of this area is due to its being covered with a much thicker mass of glacial debris, which was dropped where it now lies by a lobe of the great Laurentian ice-sheet. Since its deposition, its surface has been modified only by wind, frost and erosion by small streams. On the western border of Lake County this belt of drift is 17 miles in width. Where it passes into Porter County its width is approximately the same. In that county it trends to the northeast and gradually narrows until at the point where it leaves the county it is but seven miles in width.

3. *The Kankakee Basin or Southern Region.*—The remaining 185 square miles of the two counties are comprised in this region, 80 of them lying in Lake County and 105 in Porter. In the former county most of this area is marsh land, which up to the present has not been drained sufficiently for thorough cultivation. In Porter County the marsh area is much less, a large part of the Kankakee basin being composed of rich and, at present, well drained prairie lands.

The Middle Region and the drained portion of the Southern Region are especially noted for their production of hay. The marsh lands of the Kankakee, when drained and fertilized with some salt of potash, which in their mucky portions is the lacking element of plant food, are destined to become as productive as any lands of the State.

The railway facilities of these two counties are unequalled in Indiana. Nine great trunk lines cross both counties from east to west and in Lake, the C., I. & L. (Monon) runs almost the full length of the county from north to south. The two counties thus stand at the main door of entry into Chicago. Across their bounds all passengers to and from that city to the eastern states must travel. Besides these ten great systems, five belt railways, each connecting with almost all the roads entering Chicago, cross

a portion or all of Lake County, and one of them, the E., J. & E., extends nine miles into Porter. The principal business of these belt roads is the transferring of freight from the main trunk lines east of Chicago to similar lines running west from that city. Crossing and intersecting as they do, the Calumet region, they give to that area most excellent shipping facilities. Many capitalists have, of recent years, availed themselves of these facilities, and about Hammond, East Chicago, Whiting, Indiana Harbor, Hobart, Porter and Chesterton have been located some of the largest and most flourishing factories in Indiana. In fact, its many railways, its proximity to Chicago, and the cheap prices at which factory sites can be secured within its bounds, now mark the once despised and little valued Calumet region as one of the future great manufacturing districts of the world.

The clays of Lake County which come close enough to the surface for utilization are of two kinds, drift clays and silty or marly clays. The drift clays are utilized at Lowell, in the making of brick and drain tile, and the silty clays at Hobart, on an extensive scale, in the making of terra cotta lumber, flue linings, fire-proofing and pressed front brick.

At Lowell the clay factory was operated by the late P. D. Clark for 20 years. The amount invested is but \$8,000, and the value of the annual output is about the same, equally divided between the two products. The clay used is gotten from a hillside northwest of the town, northwest quarter section 23 (33 N., 9 W.). It is a tough, yellowish drift clay about 12 feet in thickness, with many small pebbles of lime carbonate and other material scattered through the basal portion. For this reason only the upper four or five feet are used, and this has to be passed through a crusher. Underlying the clay stratum is a thick deposit of coarse sand.

The plant is located at the base of the hill, and the clay is hauled to it in carts. After being crushed, it is passed through a perpendicular pug mill and then through a Little Wonder brick and tile machine. The products are dried by air in sheds and burned in round down-draft kilns. Aside from an occasional pebble, which escapes the crusher and causes a flaking of the surface, the brick and tile are of good quality. The clay, however, is not suited for higher grade products.

Drift clay similar to that used at Lowell lies near the surface over an area about three miles wide between Lowell and Crown Point. Only about three feet of the clay can be used on account of the pebbles in the lower portion of the bed. Brick were formerly made from this clay at Crown Point, but never on an extensive scale.

By the side of the Pittsburg, Fort Wayne & Chicago Railway, just north of Hobart, in the southwest quarter of section 29, and the southeast quarter of section 30 (36 N., 7 W.), is one of the largest, best known and most valuable deposits of silty clay in northwestern Indiana. For a long period ordinary soft mud brick were made in large numbers from the surface portion of this deposit, but in 1887, W. B. Owen began the making of terra cotta lumber and fire proof products from the deeper portions of the clay bed, and this business, now carried on under the name of the National Fire Proofing Co., has become one of the more important clay industries in the State. The pit at the yard covers an area of about six acres, and is 25 feet deep. A section of it showed as follows:

Section at Pit of National Fire Proofing Co.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil	0	6
2. Fine-grained yellowish marly clay.....	3	0
3. Grayish blue fine-grained clay.....	21	0

The two clays, Nos. 2 and 3, were, when deposited, doubtless of the same color, and the difference in hue now existing has been caused by leaching waters. No. 3 has been pierced by a bore to a depth of 132 feet without reaching its base. The deposit is a well defined silt, the upper six to 10 feet of blue clay being in layers two to six inches thick, with each layer separated from the one above and below by a thin coating of sand. Toward the bottom of the exposure the layers become thicker, eight to 14 inches, and the clay is more condensed and contains less free silica. Not a pebble or a solid body of any size occurs in the entire deposit, and it was most probably laid down by a slow deposition in the waters of a shallow bay which formed an adjunct to the highest stage of the old glacial Lake Chicago.*

*See Twenty-second Ann. Rep. Ind. Dept. Geol. & Nat. Res., 1897, p. 23.

When dry the clay becomes much lighter in color. By itself it burns to a dark cream and, when mixed with the surface stratum, to a light pinkish hue. On account of the presence of about 20 per cent. of calcium and magnesium carbonates, the clay effervesces freely with acids. Its chemical composition, as determined by Dr. Noyes, is as follows:

Analysis of Marly Clay from Hobart.

Silica (SiO_2)	50.56
Titanium oxide (TiO_2).....	1.00
Alumina (Al_2O_3)	13.11
Water combined	2.76
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Clay base and sand.....	67.43
Ferric oxide (Fe_2O_3).....	2.98
Ferrous oxide (FeO).....	2.32
Lime (CaO)	7.87
Magnesia (MgO)	5.06
Potash (K_2O)	3.74
Soda (Na_2O)70
Fluxes	22.67
Carbon dioxide (CO_2).....	9.62
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Total	99.72

The large percentage of fluxes present shows that wares from this clay can not be subjected to great heat on account of the danger of their melting down. The clay is peculiarly fitted for a light porous product, which does not require the properties of hardness or toughness.

Just across the railway from the factory of the National Fire Proofing Company is the Kulage Brick Works, probably the largest and most modern factory for making dry pressed front brick in the State.* Ordinary brick and drain tile were first made on the site of the present plant, but from numerous experiments it was found that by proper mixture, high grade dry-pressed brick of a number of different shades between a deep red and a handsome cream color can be made from the clays of the vicinity. In 1897 the owners, therefore, erected the present factory for the making of such brick.

The section exposed in the clay pit just south of the factory in October, 1904, was as follows:

* For description see under "Clay Industries of Indiana."

Section at Pit of Kulage Brick Works.

	<i>Feet.</i>
1. Soil	1
2. Yellow marly clay	5
3. Bastard bluish clay	5
4. Blue marly clay	7+

Stratum No. 2 burns to a bright cherry red; No. 3 burns pink and No. 4 maroon. A stratum of clay 15 feet thick, a short distance further south, burns to a creamy white color. By mixing in certain proportions other desired colors can be readily made. A steam shovel was being used in excavating the clay, the latter being removed to a depth of 16 feet.

The blue clay, No. 4, has been proven by bores put down in a number of places on the land of the Kulage Company, to be more than 100 feet in thickness. It is found over a large area in sections 19, 20, 29 and 30 (36 N., 7 W.), north of Hobart, and also south and east of that town, but in most places the stripping is so heavy as to prevent its utilization. In a well near the center of Hobart it was found to be overlain by 22 feet of sand. In the yard of J. A. Johnson, in the northwest quarter of section 20, seven feet of sand and six feet of yellow clay lie above it. Along Deep River it outcrops in a number of places, but usually in localities where it can not be utilized on account of the spring overflows. Its constituents and properties are the same wherever found within the limits once occupied by the bay of Lake Chicago. This is shown by the chemical analyses, printed on succeeding pages of this paper, of samples taken at Garden City, Chesteron and near Michigan City.

A fine exposure of similar clays also occurs in the Hart Ditch near Maynard, northeast quarter section 31 (36 N., 9 W.), on land controlled by D. C. Atkinson, of Hammond. A black clay loam, from two to three feet in thickness overlies the upper portion of the clay deposit. The latter is exposed to a depth of 18 feet, the lower 15 feet of which is the same fine grained bluish gray clay used for terra cotta lumber and pressed brick at Hobart, while the upper three feet is of the same quality but somewhat discolored by the leachings of the overlying soil. These clays underlie a large area near the exposure. The Pennsylvania, Grand Trunk and Monon railways run through the tract and furnish the best of transportation facilities. No better locality

exists in northern Indiana for the establishment of large factories for the making of terra cotta lumber and fireproof products of similar nature.

The same character of marly clays occur near Dyer and have been found in wells and bores at a number of other places within the former limits of the old glacial Lake Chicago.

The clays of Porter County, like those of Lake, are sedimentary in nature and belong to the two groups of "drift clays" and "marly clays." The drift clays are made into ordinary brick and drain tile at Hebron and Valparaiso, and the marly clays into pressed front brick at Porter, and ordinary brick at Chesterton.

In a cut one-third of a mile west of Hebron the Panhandle Railway has exposed the drift clays to a depth of 14 feet; disclosing the following strata:

Section in Railway Cut near Hebron.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil	1	4
2. Bluish joint clay.....	3	0
3. Hard yellow clay.....	10	0

The bluish clay immediately below the soil was broken into irregular four-sided masses two or three inches long and an inch thick. The yellow clay was a solid homogeneous body, with here and there a lime pebble or small boulder embedded in its mass. Both clays effervesced freely with acids, showing the presence of a large percentage of lime carbonate.

In the south part of the town brick were made from the upper clay for more than 30 years. The annual output was only enough to supply the local demand and varied between one hundred and five hundred thousand. Six inches of the surface were stripped and the remainder of it and two feet of the underlying clay used; all below that containing too many lime pebbles.

One half mile north of Hebron, R. S. Kenny has been making drain tile since 1895 from a clay found in the marshy ground near his plant. Six inches of the soil are removed, and four feet of the tough, bluish, very plastic clay utilized. Sand and gravel set in at about five feet and prevent the use of the lower portion of the clay bed. After passing the clay through a crusher the tile are made on an H. Brewer machine and are of excellent quality. The value of the output in 1904 was \$5,250.

In the south part of Valparaiso, Chas. F. Lembke & Co. are using the drift clay for making ordinary soft mud brick and also a harder "sidewalk" brick for pavements and foundations. The clay used is obtained on a hillside and is quite free from pebbles to a depth of five feet, but below that distance they become more plentiful, and prevent its utilization. The clay is first passed through a disintegrator, then through a Williams pulverizer and over an oscillatory-inclined screen. It is then passed through a pug mill and a Creager soft mud machine, and the resulting brick are dried on pallets in open sheds. Three round down-draft kilns, each holding 43,000 brick, are used in burning the sidewalk brick. The building brick are burned in "scove" kilns of 280,000 capacity. On account of the thorough preparation which the clay receives, the brick made are of excellent quality and find a ready market in Valparaiso, at \$5.50 per thousand, delivered. The annual output is about one million.

In the north part of Valparaiso, Coovert & Clevenger are making drain tile from clay which they obtain from a swamp one-half mile northeast of their plant. It is the characteristic tough blue clay which underlies the mucky soil of the swamps of this region. Three and a half feet are used after stripping five inches. The clay is passed through two crushers, and then through an Ohio auger machine. The resulting tile are air-dried in sheds and burned 60 hours. The value of the annual output at this plant is about \$3,000; the price for four inch tile in 1904 being \$14.00, and for ten-inch, \$75.00 per thousand at the yard.

At Garden City, two miles southeast of Hobart, on the line between Lake and Porter counties, a fine bed of marly clay occurs which was deposited at the same time and by the same agencies as the bed at Hobart. The P., F. W. & C. and the Nickel Plate railways, which here run side by side, are just south of this deposit, and a switch from the latter enters the yard of the factory which has been erected. At this factory ordinary stiff mud brick have, in the past, been made in large quantities for the Chicago market. The factory was at one time well equipped for making these brick in large numbers but, unfortunately, has been owned and managed by parties who were not practical brick men, and who, therefore, could not successfully carry on the business.

As a result it has been idle for a large part of the time during

the past ten years. At the pit the following section was exposed at the time of my visit:

Section of Clay Pit at Garden City.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil	0	8
2. Reddish marly clay.....	4	0
3. Buff sand'.....	2	0
4. Bluish gray marly clay.....	6	0
5. Bluish sand	2	0
6. Bluish gray clay, fine-grained.....	20	0

A well on the yard has been sunk to a depth of 150 feet through the bluish clay, No. 6, to gravel, and an inexhaustible supply of good water obtained. With the exception of the sand strata, Nos. 3 and 5, this deposit is very similar to the one at Hobart. The blue clay is the same fine grained, silty material, with a very similar chemical composition, as the following analysis, made by Dr. Noyes, will show:

Analysis of Bluish-Gray Marly Clay at Garden City.

Silica (SiO_2)	50.37
Titanium oxide (TiO_2).....	.65
Alumina (Al_2O_3)	9.93
Water combined	1.50
Clay base and sand.....	62.45
Ferric oxide (Fe_2O_3).....	2.10
Ferrous oxide (FeO).....	2.05
Lime (CaO)	10.26
Magnesia (MgO)	6.26
Potash (K_2O)	3.04
Soda (Na_2O}) .....	.79
Fluxes	24.50
Carbon dioxide (CO_2).....	12.50
Total	99.45

The samples analyzed were taken from near the surface of the bluish clay. If they had been gotten from a greater depth, as was the one from Hobart, the percentage of alumina would doubtless have been larger, and that of some of the fluxes less. The clay will be found to be well suited for the making of the same products as are made by the National and Kulage companies at Hobart. Experiments will also doubtless show its fitness for structural terra cotta of good quality, since its constitu-

ents are very similar to those of one of the clays used by the largest factory manufacturing that product in New York, viz., the Glens Falls Terra Cotta Co. An analysis of their clay is added for comparison:

Analysis of Terra Cotta Clay at Glens Falls, N. Y.

Silica (SiO_2)	48.35
Alumina (Al_2O_3)	11.33
Oxides of iron	4.02
Lime (CaO)	15.38
Magnesia (MgO)	3.17
Organic matter	1.18
Potash and soda	6.05
Carbon dioxide (CO_2)	10.52

The high amount of lime and magnesia in the bluish gray clays at Hobart and Garden City causes them to produce a light colored ware. A mixture of this clay with the overlying red clay produces a speckled, pinkish product, and the red clays alone a deep red product. A variety of different colored terra cotta can thus be made without the use of artificial coloring matter.

The same silty clays come near the surface in a number of places in the area formerly covered by the bay of the old glacial Lake Chicago, especially in sections 15, 22, 27 and 34 (36 N., 7 W.), Portage Township, Porter County. They are at present at too great a distance from transportation facilities, but the time will come when their value for terra cotta lumber and similar products will be better known, and to some of them railway switches will then be extended.

Near the junction of the Michigan Central and Lake Shore railways, at Porter, Indiana, is located the largest pressed front brick factory in the State. It is one of a dozen or more similar factories in different parts of the Union owned and operated by the Chicago Hydraulic Press Brick Co., and has been in operation since July, 1890. The clay used is a peculiar, fine grained, buff material, entirely free from lime pebbles, and containing but a small percentage of lime carbonate as a constituent. It covers to a depth of six feet an area of 15 acres in the northeast quarter of section 34 (37 N., 6 W.), and is also the surface clay over 200 or more acres owned by the company in sections 27, 35 and 36 in the same township and range. Below it is usually found a bed of white sand 25 or more feet in thickness.

The clay is gathered at the yard just north of the company's plant, and stored in sheds for winter use. A special harrow-shaped plow, designed and made at Findlay, Ohio, and propelled by a 12-horsepower traction engine, loosens the clay over an area six feet wide, to a depth of three inches. This plowing is done on a gradual slope, so as to get a uniform mixture of the clay and prevent uneven shrinkage in the brick. Ten rotary excavators, each holding enough clay for 300 bricks, follow the plow and gather up the clay. They convey it to the storage sheds, three in number which, when full, hold enough to make seven millions of brick.*

The same company also makes from the surface clay and underlying sand a soft mud brick in large quantities for the Chicago and other markets. Below the surface clay are three or four feet of clay and sand in alternate thin strata. These are mixed with the surface clay and made into brick on a Martin machine at the rate of 35,000 daily for six months in the year. They are dried on pallets in sheds and are burned in the lower portions of the kilns used for burning the pressed front brick. They bring \$8.00 per thousand f. o. b. the cars at the plant.

One mile northeast of Chesterton, on a spur of the Pere Marquette Railway, P. E. Anderson & Sons have been making brick and tile for 18 years. For seven years the brick were made by hand, but a Monarch soft mud and Brewer stiff mud machine are now in use. A section of the pit at this yard shows as follows:

Section of Clay Pit at Yard of P. E. Anderson.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil and surface, stripped.....	0	6
2. Yellow coarse-grained clay	5	0
3. Bluish marly clay with a few lime pebbles.....	20	0
4. Bluish gray marly clay, free from pebbles, pierced by bore.....	35	0

The uppermost clay burns to a bright cherry red color, and makes a brick far above the average in quality. The next stratum, No. 3, burns pink and is mainly used in tile making. The lower stratum, No. 4, is very similar to the clay found at Hobart and burns to a cream color. An analysis of a mixture from strata Nos. 3 and 4, by Dr. Noyes, resulted as follows:

*For descriptive account of the factory see under "Clay Industries of Ind."

Analysis of Bluish-Gray Marly Clay at Chesterton.

Silica (SiO_2)	53.02
Titanium (TiO_2)	1.30
Alumina (Al_2O_3)	10.72
Water combined	2.21
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Clay base and sand.....	67.25
Ferric oxide (Fe_2O_3).....	2.54
Ferrous oxide (FeO).....	2.22
Lime (CaO)	8.38
Magnesia (MgO)	5.28
Potash (K_2O)	3.25
Soda (Na_2O)86
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Fluxes	22.53
Carbon dioxide (CO_2).....	10.48
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Total	100.26

The products made at this factory are dried in open air sheds and burned with wood and coal. The brick are sold at the yard for \$5.00 per thousand, and the four-inch tile at \$11.00 per thousand. The clays are suited for the making of pressed front brick, terra cotta and fire proofing. The blue marly clay is said to outcrop near City West in section 18 (37 N., 5 W.), and also at the overhead bridge across the Michigan Central Railway one mile north of Chesterton.

LAPORTE COUNTY.

Laporte County is in the third tier of counties from the western line of Indiana, and lies adjacent to the south border of the State of Michigan. Its northwestern corner is bordered by the shore of Lake Michigan for a distance of seven miles. The Kankakee River, flowing southwest, forms the larger portion of its southern boundary, and receives from the county Mill Creek and several small tributaries. The area of the county is 563 square miles. Of this the northern third is somewhat broken and hilly and was formerly covered with timber. The central and southern portions contain about 200 square miles of fine prairie and a large area of Kankakee marsh land, much of which has been drained, and now forms excellent grazing and farming lands.

Numerous small lakes are scattered over the central or morainic portion of the county, and add much to the beauty of its

scenery. The largest of these are Pine, Clear and Stone lakes, just northwest of Laporte, the county seat.

Transportation facilities are most excellent, six railways crossing the county from east to west, two from north to south and one from southeast to northwest, thus furnishing an outlet in every direction.

The entire surface is of glacial origin, the Valparaiso moraine, with a width of six miles, passing northeastward across the northwestern corner of the county. The crest of this moraine lies from 225 to 300 feet above the level of Lake Michigan. This moraine "rises very abruptly on its northwest border above the low plain which lies between it and Lake Michigan, but on its southeast border a gravel outwash from the moraine is built up nearly to the level of the crest, and the descent is gradual from the moraine to the Kankakee marsh. The marsh stands fully 100 feet above Lake Michigan in eastern Laporte County, and about 75 feet at the western border of the county. It is, therefore, 150 to 200 feet or more below the crest of the moraine. The gravel plain makes a descent of 75 or 100 feet in the interval of eight to 10 miles between the moraine and the marsh.

"On the low plain bordering Lake Michigan, in the northwestern part of the county, there are series of narrow till ridges or feeble moraines which govern the drainage of that region to a marked degree, though having a relief of but 30 to 50 feet. On the intermediate border of the lake there are prominent dunes, rising in places to a height of 150 feet above the lake level."*

The thickness of the drift is known at but three places where gas well borings have penetrated to the underlying stratified rock. These are at Laporte, where it is 295 feet thick; Lacrosse, 38 feet and Michigan City, 250 feet.

The clays of the county suitable for burning are either the surface drift clays or the silty or marly clays derived from them. Along Treaty Creek, northeast of Michigan City, large deposits of an excellent bluish gray marly clay come to the surface. Two miles east of the city Roeske Bros. have, a short distance from the creek, an extensive plant for the making of soft mud brick from a deposit of this and other clays. A section at their pit showed as follows:

* Leverett. Wells of Northern Indiana, 1899, 19.

Section of Clay Pit at Roeske Bros. Plant.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil	0	6
2. Buff sand	3	6
3. Reddish loam	2	0
4. Yellow marly clay	2	6
5. Bluish gray clay.....	16	0

After stripping the soil and a portion of the sand, the remainder, down to No. 5 of the section, is used in making red brick. The loam, No. 3, can be used for lining ladles, etc., in iron furnaces. The same material is shipped in quantity to Chicago from near McCool, Porter County. The layer of bluish gray clay has been pierced by a bore to the depth of 40 feet without reaching its bottom. It burns to a whitish or cream color, and two-thirds of the output of the factory are from it alone. The deeper the point from which the clay is obtained, the stiffer and more tenacious it is, and the better the quality of brick made from it. The following analysis of this clay, made by Dr. Noyes, shows its constituents to be practically the same as the deposits so extensively worked at Hobart, Lake County, for fire proof products:

Analysis of Bluish-Gray Clay from Michigan City.

Silica (SiO ₂)	50.47
Titanium oxide (TiO ₂).....	1.45
Alumina (Al ₂ O ₃)	12.77
Combined water	3.14
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Clay base and sand.....	67.83
Ferric oxide (Fe ₂ O ₃).....	2.44
Ferrous oxide (FeO)	2.52
Lime (CaO)	8.17
Magnesia (MgO)	5.22
Potash (K ₂ O)	3.70
Soda (Na ₂ O)73
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Fluxes	22.78
Carbon dioxide (CO ₂).....	9.80
<hr/>	
Total	100.41

In the making of brick, the clay, after being weathered for some time, is passed through a crusher and then through a horizontal pug mill, after which it is elevated by a belt carrier to the top of a soft mud machine. The brick are dried in sheds and burned in a peculiar continuous kiln. This kiln is divided

into 16 chambers, each capable of holding 16,000 to 22,000 brick. After the fire is once started the fuel, which is screened coal, is put in at the top of the chamber instead of at the bottom. Each chamber is connected by pipes with the ones adjacent to it, and the heat passes from chamber to chamber and water-smokes or dries the brick. In this way little heat is lost and the brick are burned for about 35 cents per thousand. For fuel Hocking Valley coal screenings are used, costing \$2.05 per ton at the plant, as it is claimed that Indiana coal is too dirty. Aside from their color, the brick made from the blue clay at this factory are of excellent quality. When burned very hard they become a greenish cast and are then used for paving alleys, sidewalks, etc., and are sold at \$9.00 per thousand, delivered. The ordinary quality bring \$6.00 per thousand at Michigan City.

As already noted, the same clay as is used by Roeske Bros. outcrops in quantity along Treaty Creek. The L. E. & W. Railway runs over some of the best deposits. There is thus room and excellent facilities for the erection in this vicinity of several large factories for the making of fire-proofing, terra cotta, pressed front brick and other products. Too high a percentage of fluxes are present for the utilization of the clay in making sewer pipe, paving brick and similar vitrified wares.

A strip of clay land, from three to four miles wide, runs in a northeasterly-southwesterly direction, from the eastern line of the county, to Otis in the western part. The surface clays of this strip are, in general, suitable for brick or tile making. A lack of transportation facilities and fuel forms the great drawback to their development.

At Laporte ordinary building brick are made at one yard; a surface drift clay, five feet thick, being used without stripping.*

ST. JOSEPH COUNTY.

St. Joseph County lies east of Laporte and is bounded on the north by the state of Michigan. It comprises an area of 477 square miles, the surface of which is diversified by prairies, marshes, oak openings, and rolling timber land. The oak openings are covered with a light sandy soil, excellently suited to the

* See statistical table at end of paper.

raising of small fruits; the timber lands possess a subsoil of clay, covered with a rich dark soil which, under proper cultivation and rotation of crops, yields all the cereals in abundance. The prairies, both old and young, for the marshes are but incipient prairies, where properly drained, are unexcelled for the raising of any farm product except wheat, which in places winter kills.

The Kankakee River rises about two miles southwest of South Bend, and flows in a southwesterly direction through the county. The most of the marsh land adjacent to it has been or is being drained. The St. Joseph River is the principal stream within the county; entering it a little north of the middle of the eastern boundary, flowing westerly about ten miles, and then northerly into the state of Michigan. On its great bend to the northward is the flourishing city of South Bend, possessing a population of almost 50,000, and noted for its manufactures, especially wagons and plows, which are shipped to all portions of the world.

Six important railways pass through the county; the Lake Shore & Michigan Southern; the Grand Trunk; the Michigan Central; the Indiana, Illinois & Iowa, commonly known as the "Three I"; the Logansport Division of the Vandalia, and the Chicago Division of the Wabash. The Baltimore & Ohio and Lake Erie and Western cross the southwestern corner, their junction with that of the Three I being at Walkerton, while the Michigan Division of the Big Four cuts the northeastern corner. Most excellent transportation facilities are thus furnished in every direction.

There is not an outcrop of rock in the county, the entire surface being covered with glacial drift which will probably average 200 feet in thickness. The only place where this drift has been pierced to the underlying stratified rock is at South Bend, where it was 137 feet thick. This, however, was in the valley of the St. Joseph River and only 725 feet above tide, or fully 150 feet lower than the uplands in the southeastern portion of the county. The drift over about one-half of the county is a gravel plain formed by the outwash from the ice sheet. "In the northwestern portion of the county the outwash is from the Valparaiso moraine, and the plains descend from about 800 feet at the border of the moraine to 725 feet at the border of the Kankakee marsh.

In the southwestern portion of the county the outwash is westward from the Maxinkuckee moraine of the Saginaw lobe, and there is a similar descent from the moraine to the Kankakee marsh. In the northeastern portion of the county there is an extensive gravel plain along the St. Joseph River, whose head is in southern Michigan in a later moraine of the Saginaw lobe. The southeastern part of the county is occupied by a till plain which borders the Maxinkuckee moraine on the east. The Maxinkuckee moraine passes diagonally across the county from the southwest to the north border and has a width of about five miles. It is interrupted by a gap at the St. Joseph River near South Bend two or three miles in width. The highest portions of this moraine stand fully 300 feet above Lake Michigan or about 900 feet above tide.”*

Wells sunk through the gravel plain above mentioned strike no clay until at a depth of 60 or more feet. Those on the Maxinkuckee moraine, about eight miles south of South Bend, pass through 22 feet of yellow clay, and then through alternating layers of sand and blue clay for a depth of 100 feet before reaching gravel.

The clays of St. Joseph County, which have been found the best suited for manufacturing, are in the immediate vicinity of South Bend. Along the lowlands and terraces of St. Joseph River are thick deposits of a pearl-gray marly clay, exceedingly fine grained and plastic, which for many years has been made into light yellow building brick or, when burned harder, into a darker, greenish-yellow paving brick. At the old pit of the Soen's Brick Co., in the eastern part of the city, the different strata exposed show as follows:

Section at Old Clay Pit of Soen's Brick Company.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil	0	8
2. Sand, coarse-grained, reddish, impregnated and discolored with iron oxide.....	4	6
3. Gravel	3	0
4. Sand, gray	3	0
5. Clay, bluish gray.....	15	0

From this bluish-gray clay, which in places is 50 feet thick,

* Leverett. Wells of Northern Indiana, 1899, 21.

the Soen's Brick Co. made, for years, the two kinds of brick above mentioned. The deposit was evidently laid down in still water, since it is wholly free from pebbles. Aside from the heavy striping, which is a great drawback to securing it in proper quantity, the clay is well suited to the uses to which it is put. In places small pockets of so-called quicksand occur, which lessen to some extent its value. The lower half of the clay stratum is better suited for burning the hard brick used for paving purposes. The clay effervesces very freely with acids, and probably contains 10 to 15 per cent. of the carbonates of lime and magnesia. This yard has been abandoned since 1901.

On the east side of the river, about one-half mile north of Soen's yard was, for a long time, another large yard owned and operated by Leeper & Longley. Their clay pit was in the second bottom or terrace of the St. Joseph River and a section exposed was as follows:

Section of Clay Pit at Old Yard of Leeper & Longley.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil	8	0
2. Sand and loam	4	0
3. Coarse gravel	5	0
4. Bluish gray marly clay.....	18+	0

The clay has been proven by bores to be 50 feet thick. Brick made by this firm in 1888 were used in paving two blocks of a street that has been much used for 16 years, and shows as yet but few signs of wear.

In 1903 the South Bend Brick Co. was organized and purchased the remaining interests of the yards above mentioned. A new tract of 161 acres was secured along the St. Joseph River, a mile and a half north of the city. On it a modern, well equipped factory was built, and connected by a spur with the Michigan Central Railway. Here, in June, 1904, the company began the making of stiff mud ordinary brick from the lowland deposits of clay. The factory is the only one of the kind in the State which is run wholly by electric power. This is furnished by the South Bend Electric Co., which has large plants at Buchanan, a town on the St. Joseph River, 14 miles north, and at Hen Island above Mishawaka. At the plant 100-horsepower is developed from a 23,000 volt motor.

A well sunk on the grounds to a depth of 88 feet went through four feet of sand and gravel, 75 feet of clay, four feet of black sand, and secured water in gravel. The surface layer of sand and gravel is stripped and in part screened. One part of the resulting sand is mixed with three parts of the underlying clay, the pit being opened to a depth of 12 feet.

The clay is hauled from the pit to the plant in tram cars. It is first passed through a disintegrator, then through a 14-foot pug mill and a Raymond brick machine. The output is 60,000 daily. The brick are dried for 24 hours by direct heat, and then burned in 20-arch kilns, holding 500,000 each, for eight days, with Greene County mine run coal costing \$2.35 per ton laid down. They are uniform in size and weigh five pounds each. In 1904 they sold for an average price of \$6.12 per thousand delivered in the city.

The blue marly clay used at the present and the old yards ranges from 30 to 80 feet in thickness. It evidently covers a large area, since it overlies a bed of gravel, from which is secured the water supply of the city. The clay forms an impervious cover for this water-bearing stratum, and when pierced the water rises from two to ten feet above the surface. At the site of the old waterworks, in the eastern part of the city, 32 wells have been put down 112 feet deep. An average section of these wells is as follows:

Average Section of Wells at Old Water Works, South Bend.

	<i>Feet.</i>
1. Soil and sand.....	12
2. Blue clay	40
3. Sand	40
4. Gravel	20

At the new water station on North Michigan Street are 30 wells, the average section of which is:

Average Section of Wells at New Water Works at South Bend.

	<i>Feet.</i>
1. Soil and sand.....	14
2. Gravel	3
3. Blue clay	30
4. Sand	22
5. Gravel	14

The brick made from this blue clay are hard, tough and durable. If the proper kilns and other facilities were erected, paving material of good quality could doubtless be made from it; but it is better suited for terra cotta, fire proofing, flue linings and those numerous other products for which the ever increasing number of fire-proof buildings is creating a constantly growing demand. Terra cotta lumber, such as is made at Hobart, Lake County, by the National Fire Proofing Co., could, without doubt be made from the clay, and the industry, if properly managed, would be a growing and profitable one. It could also be used as the clay ingredient of Portland cement, a very similar clay from La Paz, in Marshall County, just south, being used for that purpose at Syracuse, Ind.

About two miles southwest of South Bend are three factories* which make soft mud brick from a buff, porous, loamy drift clay. This material, to a depth of four to nine feet, is free from carbonate of lime or lime pebbles, and burns to a handsome dark red. The brick made from it are hard, tough and durable, and above the average of those which go into the inner and side walls of buildings. The clay covers a large area in sections 21 and 22 (37 N., 2 E.), being found on the surface of the Maxinkuckee moraine, which here rises 30 to 40 feet above the Kankakee marshland to the northward.

At the yard of Frank Fisher, in section 22, the clay used, after stripping eight inches of surface, averages four feet in thickness and overlies a darker clay which contains pebbles of lime. Beneath the latter is the characteristic blue clay of the region. Coal, costing \$3.40 per ton laid down at the yard, is used as fuel, 30 tons being required to burn 275,000 brick.

One-half mile southwestward, at the yard owned by the South Bend Brick Co., the porous buff clay runs 6 to 10 feet in thickness, and overlies a hardpan three feet in thickness, containing numerous pebbles. Beneath the latter is a bed of sand of unknown thickness. The three yards in this locality use soft-mud machines, dry on pallets and burn with coal. Their combined output in 1904 was about 5,000,000, which were sold in South Bend at \$6.00 per thousand. The buff clay is not suited for the making of drain tile, as it runs too high in silica.

*See statistical table at end of paper.

Near Woodland, in the southeastern part of the county, Mochel Bros. are making drain tile 3 to 12 inches in size and ordinary brick from a 15-foot deposit of surface clay. Wood, costing \$3.00 per cord, is used as fuel.

ELKHART COUNTY.

This county is bounded on the north by the State of Michigan, on the east by Lagrange and Noble counties, on the south by Kosciusko, and on the west by Marshall and St. Joseph. It is quadrangular in outline, and contains an area of 465 square miles.

The St. Joseph River enters the county from Michigan, about six miles west of the northeast corner, and flows in a southwest course into St. Joseph County. At Elkhart it receives its principal tributary, the Elkhart River, which drains the southeastern portion of the county. Both the St. Joseph and the Elkhart are dammed in numerous places, and furnish cheap and excellent water power for many extensive factories, especially at Goshen and Elkhart.

The county is well supplied with railways. Three divisions of the Lake Shore & Michigan Southern traverse its bounds, while the Michigan Division of the Big Four and the Chicago Division of the Wabash pass entirely through it, the former in a north and south direction, the latter east and west along the north border of the southern tier of townships. The Baltimore & Ohio also cuts across the southwestern corner.

In common with the counties adjoining, the surface of Elkhart is wholly covered with drift, the thickness of which is known at but three points, viz., Elkhart, Goshen and New Paris, where it is, respectively, 122, 162 and 90 feet. The surface of this drift is more level than in the counties to the east and south, an area of about 200 square miles in the northwestern and southeastern parts of the county being composed of extensive gravel plains. The uplands consist of till plains, with an area of 125 square miles, in the southwest part of the county, and of morainic belts, more broken, in the southern and western portions. The wells sunk in the vicinity of Elkhart penetrate a thick stratum of blue clay and obtain water in a coarse gravel near the bottom of the drift. At Goshen a stratum of blue clay 19 feet in thickness underlies a two to five-foot layer of surface sand. In the southwestern

part of the county the surface yellow clay runs six to ten feet thick, below which is sand or gravel and then a thick stratum of blue clay.

Along the St. Joseph River west of Elkhart are found extensive deposits of the plastic blue-gray marly clay described above under the clays of St. Joseph County. At the John C. Boss yard, three miles west of Elkhart, this clay occurs 18 to 90 feet in thickness beneath six to eight feet of sand and gravel. It is here used extensively for the making of light-colored building brick. The upper four feet of the clay has been used in recent years as a slip clay for glazing stoneware. Mr. Boss reports a sale of 100 tons for such purpose in 1904. This brought \$2.50 per ton f. o. b. at the yard. The Elkhart Brick Co. uses the same clay at a point a half mile east of the Boss yard. At their pit about 14 feet of the blue clay is exposed beneath three to seven feet of surface gravel and sand.*

At Goshen two yards are making soft mud red brick from a "tough yellow surface clay." The latter runs 18 or more feet in thickness, but only the upper two to six feet can be used on account of lime pebbles.

Of the clays near Goshen Mr. George Bemenderfer, owner of one of the yards, writes: "A well on our yard, in the northwest quarter section 34 (37 N., 6 E.), two miles north of Goshen, shows the following section:

Section of Well on Bemenderfer Yard.

	<i>Feet.</i>
1. Soil	1
2. Tough yellow clay	18
3. Sand	6
4. Blue clay	20+

"We are making a very good red brick from the yellow clay, but using only two feet from the surface on account of lime. We made a few brick from the blue clay, which did not shrink in drying or burning. We tried to melt them in our kiln, but could not get heat enough, as the yellow clay melted at too low a temperature. We also had some of the blue clay brick in the fire box of a large boiler for two years, and the heat had no effect upon them. I thought, therefore, that the blue clay might make good fire brick."

*See statistical table at end of paper.

LAGRANGE COUNTY.

On the northern border of the State, and in the second tier of counties from its eastern boundary, is Lagrange, which contains one of the most fertile sections of northern Indiana. It has an area of 393 square miles, and lies between Elkhart and Steuben counties and north of Noble County.

The elevation of the county is between 897 and 1,027 feet above tide, and the whole area is covered with drift from 100 to 200 feet or more in thickness, the bottom of which has rarely if ever been reached. "The general surface slopes gently to the north, except the lake region of Johnson Township, which is drained southward into the Elkhart River, the crest of the divide being near Valentine. It lies entirely upon the Saginaw side of the Saginaw-Erie interlobate moraine of Chamberlain, and contains no Erie drift, except possibly at the southeast corner. It is crossed by two terminal moraines of the Saginaw glacier, so that about one-half of the county presents a topography of a distinctly morainic character, but its outlines and distribution are so irregular as to almost defy description in words."*

The county is well supplied with railways. The G. R. & I. crosses it from north to south near the center, passing through Lima, Lagrange and Wolcottville. The Chicago Division of the Wabash runs along its southern border, crossing the G. R. & I. at Wolcottville. The Goshen Branch of the Lake Shore & Michigan Southern crosses the northwestern corner, passing through Shipshewana and meeting the G. R. & I. at Sturgis, Mich., six miles north of Lima.

The prevailing soil of Lagrange County is a sandy loam, varied by gravel and gravelly clay. A boring for water on the jail yard at Lagrange penetrated 15 feet of yellow clay, beneath which was 50 feet of blue clay, alternating with thin beds of sand. Of four wells sunk for a public water supply within the town, whose sections are given by Dr. Dryer, but one passed through yellow clay, which was 12 feet thick, beneath four feet of soil and sand. The other three entered blue clay at depths of 20 to 30 feet. A well in the southeast part of the county, one-half mile east of South Milford, passed through 20 feet of sandy yellow clay into a 49-foot bed of blue clay.

*Dryer. Geol. of Lagrange Co., 18th Ann. Rep. Ind. Dep. Geol. & Nat. Res., 1893, 101.

The clays of the county are, so far as noted, surface drift or alluvial clays, no deposits of silty or marly clays, such as occur to the west, having been seen, though such doubtless occur about some of the many lakes. These clays are worked only at Topeka and at a place about three miles north of Wolcottville. At Topeka the surface yellow clay, to a depth of four feet, is used in making ordinary brick, the output being but about 275,000 per annum. At the yard north of Wolcottville, in the southeast quarter of section 21 (36 N., 10 E.), a stratum of clay of somewhat peculiar qualities is worked. It crops out beneath a few feet of sandy loam, and is from 2 to 16 feet thick. The upper portion burns to the ordinary red color and is easily fused. The lower portion, at successively higher temperatures, passes through pink and delicate cream to a yellowish green color, and is not readily fused. The capacity of the factory is \$3,500 worth of drain tile per season and 20,000 common brick and 10,000 pressed brick per day. The common brick are very durable for outside work. The pressed brick are fine in finish, and their delicate tints render them very desirable for veneering, fireplaces and ornamental work of all kinds.

A very fine-grained, plastic clay occurs over quite an area in the southwest quarter of section 1 (36 N., 11 E.), about one mile north of the Wabash Railway. For four years it has been utilized as the clay ingredient of all the Portland cement made at the large factory of the Wabash Portland Cement Co., located at Stroh, about two miles to the southeast. A section of the main pit shows about as follows:

Section at Clay Pit of Wabash Portland Cement Co.

	<i>Feet.</i>	<i>Inches.</i>
1. Sand	1	3
2. Clay	7	0
3. Clay mixed with pebbles.....	3+	0

The clay No. 2 ranges from $2\frac{1}{2}$ to 12 feet in thickness, but only the upper six feet are used, after stripping the sand, the remainder containing too many pebbles of lime and other minerals of drift origin to be available for cement making. The clay used is light brown and very free from grit. It may be classed as exceedingly pure for a clay of glacial origin, resembling closely the yel-

low loess clays of southwestern Indiana. An *average* of eight analyses of this clay, kindly furnished by Mr. Oglesbey, the former chemist at the plant, is here given; also an average analysis furnished by W. B. Cady, the present chemist:

Average of Eight Analyses of Surface Clay Used for Portland Cement Making at Stroh, Indiana; Oglesbey, Chemist.

Silica (SiO_2)	56.74
Alumina (Al_2O_3)	19.43
Ferric oxide (Fe_2O_3).....	4.83
Lime (CaO)	7.27
Magnesia (MgO)	3.05
Loss on ignition	10.39
<hr/>	
Total	101.71

Analysis of Surface Clay Used for Portland Cement making at Stroh, Indiana; Cady, Chemist.

Moisture	3.63
Silica (SiO_2)	59.20
Alumina oxide (Al_2O_3).....	17.20
Iron oxide (Fe_2O_3).....	3.00
Calcium carbonate (CaCO_3).....	9.71
Magnesium carbonate (MgCO_3).....	4.20
Sulphuric anhydride (SO_3).....	.60
Alkalies, etc., by difference.....	2.46
<hr/>	
Total	100.00

The clay covers about 10 acres belonging to the Wabash Portland Cement Company, but there are other large deposits in the near vicinity. Mr. Cady states that it "is suitable in every respect for the manufacture of a first-class Portland cement, and costs us 17 cents per ton delivered at the plant, the only expense, other than freight, being the wages of 10 men used in hauling and handling same, at \$1.75 per day."

In addition to serving as the clay ingredient of Portland cement, the quality of this clay would justify its use for high-grade pressed-front brick, terra cotta, encaustic tile, etc.

STEBEN COUNTY.

This county occupies the extreme northeastern corner of the State of Indiana. It is bounded on the north by Michigan, on the east by Michigan and Ohio, on the south by DeKalb County, Indiana, and on the west by Lagrange County. Its area is 311 square miles. The entire county, except a valley in the southeastern corner, is more than 900 feet above sea level, and it is estimated that more than one-half of the county is over 1,000 feet above, while occasional points rise to 1,150 feet. With the exception of Randolph County, its average height above sea level is probably greater than that of any other county in Indiana. This great elevation is not due to an elevated rock surface, but to the heavy accumulations of drift which everywhere cover the underlying sedimentary rocks to a depth of 300 to 600 feet. The deposition of the drift has been, in most parts of the county, very uneven, and has given rise to a remarkable group of rounded hills and irregular valleys, which has rendered the surface picturesque to a degree, hardly surpassed by any county of the State.

As yet the county is but fairly well supplied with transportation facilities. The Fort Wayne Branch of the Lake Shore & Michigan Southern Railway enters the county near the middle of its southern boundary, and runs through it in a northeasterly direction, leaving it at the station of Ray, three miles west of the northeastern corner. The Chicago Division of the Wabash System runs east and west along the southern edge, crossing the L. S. & M. S. at Steubenville. This leaves a large area of the western and northwestern portions of the county distant 12 to 17 miles from a railway. Several electric lines have been proposed through this section, and one or more of them will doubtless be soon constructed.

In this county, as over the heavy drift-covered area generally, a yellow clay occurs just beneath the soil, and overlies either blue clay or gravel. On the grounds of the Tri-State Normal College, at Angola, a well sunk to a depth of 104 feet penetrated 20 feet of yellow clay, 3 feet of blue clay and 75 feet of reddish, gravelly clay before reaching a water-bearing gravel. A well sunk on the moraine west of Angola to a depth of 130 feet penetrated yellow and blue clays for most of the distance, as did also one 100 feet

deep three miles west of Hudson and one 103 feet deep two miles southwest of Metz.

The yellow surface clays of the county furnish easily accessible deposits of most excellent brick-making material. In the low-lands about the margins of some of the lakes marly or silty clays also occur, which can be used not only for brick, but also for terra cotta lumber, fireproofing and similar products. At the present time these clays are utilized only at Angola, where two factories are in operation.* At the yard of the Angola Brick & Tile Co. three kinds of clay are used, viz., (a) yellow surface drift clay, 18 inches to 2 feet thick, that burns red; (b) yellow marly clay, three to five feet thick, that burns white or buff; (c) blue marly clay, six to eight feet thick, that also burns white to buff. The surface clay (a) is overlain with six inches of soil, which is stripped. The yellow and blue marly clays form one bed, which is overlain with three to four feet of sand. The leachings of this sand have discolored the upper portion of the underlying clay, changing it from bluish gray to buff.

At the yard of Charles A. Bachelor the clay in the pit is exposed to a depth of 25 feet, the upper four feet being ordinary yellow clay, which burns red, the lower 21 feet a bluish gray silty clay in thin layers, with a coating of sand between them. This burns to a buff or straw color. Soft mud brick and drain tile are made at both yards from these clays, but the marly clays could be burned into hollow fireproof products of many kinds. They could also be used in connection with the marl found so abundantly in many of the lakes of Steuben County in the making of Portland cement, very similar marly clays from La Paz, Marshall County, being used for that purpose at the large works of the Sandusky Portland Cement Co., at Syracuse, Ind. They will be found especially fitted for terra cotta lumber, such as is made at Hobart, Lake County, and a factory for such wares in this part of Indiana would prove an assured success.

* See statistical table at end of paper.

DEKALB COUNTY.

This county comprises an area of 369 square miles, and lies just south of Steuben, on the eastern boundary of the State. The whole county is covered by a heavy mantle of drift, which borings show to be in some places 400 feet thick, and it is probable that the rock nowhere approaches nearer to the surface than 200 feet. Except a small portion in the northwest corner, it is drained by the St. Joseph River and its tributaries. Over the greater part of the county there is a till plain, whose surface ranges from 850 to 900 feet above tide. The northwestern corner is occupied by the interlobate moraine of the Erie and Saginaw lobes, portions of which rise above the 1,000-foot contour.

The railway facilities of the county are excellent. Two trunk lines pass through it from east to west, while a third touches its northern border. Two important divisions of these lines run north and south, while a third road runs diagonally from northeast to southwest, thus furnishing ample outlets in all directions.

The till plain, which covers the greater portion of the county, is composed mostly of yellow and blue clays to a depth of 50 feet from the surface. Below this clay the drift appears to be very largely sand and gravel. At Waterloo the surface clays run 40 feet in thickness; at Garrett, about 50 feet. A well on the farm of C. Hirsch, near Spencerville, showed the constituents of the drift to be arranged as follows:

Section of Well near Spencerville.

	<i>Feet.</i>
1. Yellow clay	10
2. Blue clay	59
3. Fine sand	120
4. Gravel	9+

Of the clays of the county Dr. Charles Dryer has written as follows:

"Throughout the innumerable variations of soil in Dekalb County one law prevails: upon the elevations the soil is clay, in the valleys sand and gravel. The railroad cut at Corunna shows 18 feet of clay underlaid by coarse sand, and this is a typical specimen. Continued observation has deepened the impression that the whole region was originally covered by a sheet of clay,

which subsequent erosion has cut through and removed, except upon the higher points. The source and manner of deposit of this upper member of the drift is still an open question. That it was the surface load of the glacier and deposited by the final general melting of the mass, that it is the sediment from the waters of a post-glacial lake, and that it was dropped by floating icebergs are each possible, but hardly satisfactory, theories. During the post-glacial subsidence of the waters and the rearrangement of materials some remarkable results were accomplished. On the farm of A. Stapleton, section 31, Stafford, in a basin of about ten acres extent, under three or four feet of quaking muck, has been found a bed of calcareous clay of unusual character. Its color is a very delicate light gray, which darkens a little on exposure to the air. When wet it is so smooth and unctuous as to have led to the belief that it contains oil. When dry it forms a compact mass, which can be polished until the surface resembles glass or marble. The dry powder is as fine and soft as flour, without a particle of grit. It is alkaline in reaction and acts as a very efficient cleansing, scouring and polishing agent for all surfaces. On account of its tenacity it can be molded into the most delicate ornamental designs, and specimens of pottery made from it burn extremely hard and of a light terra cotta color. The following analysis shows its chemical composition:

Analysis of Marly Clay from Land of A. Stapleton.

Silica (SiO_2)	37.32
Alumina (Al_2O_3)	29.85
Calcium carbonate (CaCO_3).....	15.00
Magnesium carbonate (MgCO_3).....	1.84
Ferric oxide (Fe_2O_3).....	4.52
Water, combined	11.47

"Its physical characters are more remarkable than its chemical. It is genuine 'rock flour,' which can be produced in no other way than by

* * * the slow and ponderous creep
Of ice a thousand fathoms deep.

"By what delicate adjustment of currents was this flour sorted out from all admixture of coarser particles and finally deposited by slow settling from still water until the basin of the little lake was filled with it to a depth of more than 20 feet? It is a product

of glacial action as peculiar and characteristic as striated stones, and it ought to be distinguished by the name of glacierite.”*

The clay, as described, is evidently one of the silty or marly clays found about the lakes in many of the counties of northern Indiana. Wherever found, such clays will be found suitable for hollow fireproofing, and especially terra cotta lumber. All of them burn to a white or straw color on account of the high percentage of lime present.

Brick and drain tile are being made in Dekalb County at present at Auburn, Garrett, Altona, Waterloo and Moore.† At the yard of W. D. Miller, three miles northeast of Auburn, three to four feet of yellow drift clay are used, after stripping eight inches of surface, in the making of drain tile. At Altona six inches of black soil are stripped and the underlying clay used to a depth of four to six feet in making drain tile. At Auburn Grogg Bros. use a “yellow clay mixed with sand to a depth of three and a half feet in making soft mud brick.”

NOBLE COUNTY.

Noble County is in the second tier of counties south of Michigan and in the second tier east of Ohio. It is bounded on the north by Lagrange, on the east by Dekalb, on the south by Allen and Whitley and on the west by Elkhart and Kosciusko counties. The county contains 417 square miles, and lies between 868 and 1,018 feet above sea level, the lowest point being the Elkhart River, on the western line of the county, and the highest the summit in Wayne Township, three miles east of Kendallville.

The county is well supplied with transportation facilities, being crossed by three railways and touched by two more. The G. R. & I. passes north and south through the eastern part, the B. & O. east and west through the center, and the L. S. & M. S. east and west through the northern tier of townships. The Eel River Division of the Vandalia crosses the extreme southeastern corner, while the Chicago Division of the Wabash touches the northern border for about three miles in Orange Township.

The surface of the entire county is deeply covered with drift, the known thickness of which ranges between 169 and 485 feet.

* Geol. of Dekalb Co. in 16th Ann. Rep. Ind. Dep. Geol. & Nat. His., 1888, 102.

† See statistical table at end of paper.

The greater part of this drift covering belongs to the interlobate moraines of the Erie and Saginaw lobes. The Salamonie or Third Erie moraine crosses the southeastern corner of the county, forming the surface of Swan and a small portion of that of Greene and Allen townships. The Mississinewa or Fourth Erie moraine covers all the townships of Greene, Jefferson, Allen, Orange and Wayne. The western part of the county is covered with the Saginaw Drift. On account of the intermingling or merging of debris from so many different glacial invasions, the surface of the county is extremely diversified. High rounded domes, hills and ridges alternate with deep valleys and level plains in rapid succession. Many of the depressions form water-tight basins, occupied by lakes either present or extinct. The latter far outnumber the former, the combined area of the marshes, which occupy the sites of former lakes, being estimated at 15 per cent. of the total area of the county. Many of these marshes still retain a small pool of open water at the center, the last vestige of a once noble expanse of water, whose area has become gradually lessened by the encroachment of aquatic vegetation and by the dredged ditches of mankind.

The Erie slope is characterized by a heavy deposit of boulder clay upon all the higher points, sand and gravel being found only in the valleys, the result of the wash of streams. On the Saginaw slope absolutely no clay occurs near the surface, everything, from the highest hilltops to the lowest depressions, being composed of coarser or finer sand and gravel, except where covered by deposits of peat. The thickness of the drift in Noble County is known at three points—Ligonier, Kendallville and Albion. At Kendallville it is 485, at Albion 375 and at Ligonier 165 feet in thickness. The average thickness for the entire county may be estimated at 350 feet.

At Albion the beds of surface yellow clay and underlying blue clay have each been found to be 10 feet in thickness, with thick beds of sand and gravel and alternating thinner beds of blue clay beneath. At Kendallville the surface yellow clay runs 5 to 10 feet in thickness, with sand or gravel beneath, though at one point 28 feet of yellow clay was disclosed.

Three miles east of Kendallville, in section 1, Allen Township, the yellow clay is 14 feet thick. It is said by Leverett that the

blue clay of the Erie moraine found south of Kendallville is much harder to penetrate than the clay of similar color north and west of that city. A well one mile south of Kendallville showed the drift constituents to be arranged as follows:

Section of Well One Mile South of Kendallville.

	<i>Feet.</i>
1. Yellow clay	20
2. Hard blue clay.....	40
3. Cemented gravel	15
4. Water gravel	10

Northwest of Albion, near Rome City, the yellow clay runs up to 20 feet in thickness, with 40 to 45 feet of a soft blue adhesive clay beneath. Near Skinner Lake, three miles west of Albion, a well passed through 12 feet of yellow and 52 feet of soft blue clay before striking a water-bearing sand. At Ligonier the yellow clay runs 10 to 20 feet in thickness above a water-bearing stratum of gravel.

The upper portions of these surface drift clays, where sufficiently free from gravel, and the marly or silty clays found below the muck in the many marshes and about the margins of the lakes can be utilized for manufacturing clay wares, the former mainly for soft mud brick and drain tile, the latter for similar wares and also for hollow fireproofing. At the present time only the drift clays are utilized at Albion and Kendallville. At Albion but two to three feet of the surface clay can be used, the lower portion being full of pebbles.

KOSCIUSKO COUNTY.

Kosciusko, one of the largest counties in Indiana, lies near the center of the second tier of counties south of the Michigan line. It is bounded on the north by Elkhart, on the east by Noble and Whitley, on the south by Wabash and Fulton and on the west by Marshall and Fulton counties. Its total area is 521 square miles.

Three railways run entirely across the county—the Michigan Division of the Big Four north and south through its center; the Pittsburgh, Ft. Wayne & Chicago and the New York, Chicago & St. Louis (Nickel Plate) east and west, the former through the center, the latter across the middle of the south half. In addition to these the Baltimore & Ohio cuts across the northeastern corner,

while the Eel River Division of the Vandalia just touches the southeastern corner.

The continental divide, separating the Mississippi and Great Lakes drainage systems, passes through the northern third of the county in a northeast-southwest direction. The streams and lakes in the northern tier of townships are, therefore, drained through tributaries of the St. Joseph River into Lake Michigan, while those of the remainder of the county are tributary to the Tippecanoe River, one of the main branches of the Wabash. The Tippecanoe enters the county from the east, a little north of the center, and flows across in a westerly-southwesterly course. The streams of the extreme southern part drain into Eel River, also a tributary of the Wabash.

The entire surface of Kosciusko County is covered with a heavy mantle of drift, which is largely sand and gravel. The thickness of this is known only in the vicinity of Warsaw, the county seat, where two bores for gas wells showed it to be, respectively, 247 and 255 feet, while in a third, three miles west of Warsaw, it was 243 feet. The eastern and southern portions of the county are situated on the interlobate moraine of the Saginaw and Erie lobe, except the extreme southeastern portion, which is occupied by a moraine of the Erie lobe. The northwestern portion of the county, comprising about one-fourth of its area, is occupied largely by gravel plains and by marshes. The general elevation of these plains is about 800 feet above tide. The moraine stands 920 feet or more in its higher portions.

Over the northern part of the county, in the vicinity of Milford, Oswego and North Galveston, almost all surface wells penetrate sand and gravel 15 to 25 feet thick before reaching clay. At Atwood and Etna Green the yellow clay runs up to 20 feet in thickness. Around Turkey Lake blue clay is found at a depth of 12 to 15 feet, while from two to four miles east of Warsaw the wells are largely through clay beds and have a depth of 18 to 40 feet. The surface clays are utilized for brick and tile only at three or four different yards in the county.* One mile north of Warsaw two and a half feet of yellow surface clay is used without stripping for making brick, while at Nappanee both brick and tile are made from three to four feet of surface clay, after removing

*See statistical table at end of paper.

eight inches of black loam. At Packerton tile from 3 to 12 inches in size are also made from surface clay, the thickness of the workable portion ranging from 18 inches to 3 feet, while at Silver Lake a "tile clay" five feet thick is utilized.

MARSHALL COUNTY.

Marshall County lies south of St. Joseph, in the second tier south of the Michigan-Indiana line. It is bounded on the east by Elkhart and Kosciusko, on the south by Fulton and on the west by Starke and St. Joseph counties. In outline it is almost square, and contains an area of 440 square miles. The Tippecanoe River forms a loop in the extreme southeast corner, entering three miles north and leaving three and a half miles west of the corner. Yellow River is formed by the junction of its three main branches in the northeastern part of the county, and, flowing in a south-westerly direction, leaves the western edge on the line between West and Union townships. Yellow Bank and Pine Creeks, tributaries of the Kankakee, drain the northwestern fourth of the county.

Railway facilities are ample, three great trunk lines, viz., the Baltimore & Ohio, Pittsburgh, Ft. Wayne & Chicago and "Nickel Plate," crossing the county from east to west, while the Logansport Division of the Vandalia crosses from north to south and the Lake Erie & Western from southeast to northwest. Three of these lines converge at Plymouth, the county seat, and furnish an excellent outlet in all directions.

The entire county is covered with glacial debris, the bottom of which has been reached only at Plymouth, where stratified rock was found at a depth of 242 feet. The prominent Maxinkuckee moraine passes through the western range of townships from south to north. In the southwestern part of the county it forms a series of morainic knolls and ridges about Lake Maxinkuckee, which add much to the attractiveness of the scenery about the lake. Outside of the area covered by this moraine the surface of the county is, for the most part, a gently undulating plain, broken only by shallow ravines and valleys formed by the erosion of the streams above mentioned.

Over the greater part of the county the surface of the drift is

mainly sand or gravel. At Bremen, in the northeastern part, there is a small ridge, formed mainly of clay. One well in the western part of the village passed through 100 feet of blue clay. In the vicinity of Plymouth the first clay occurs at a depth of 40 to 50 feet. Flowing wells occur along the Yellow River bottoms, also along Yellow Bank Creek, near Teegarden. At the latter place much blue clay is passed through before reaching the water-bearing horizon. Around the borders of Lake Maxinkuckee are a number of flowing wells. Two of these, on the northeast shore, are 72 feet in depth and have the following section:

Section of Flowing Wells on Northeast Shore of Lake Maxinkuckee.

	<i>Fest.</i>
1. Soil and yellow clay	8
2. Sand	14
3. Blue clay	38
4. Sand and gravel	12

Near the Highland House D. W. Morman, of Indianapolis, has several wells, in the deepest one of which the water flow was obtained from the sand above the blue clay, the section being as follows:

Section of Morman Well, Lake Maxinkuckee.

	<i>Fest.</i>
1. Yellow clay	11
2. Sand	25
3. Blue clay	62

The commercially available clays of Marshall County are the surface drift clays and the silty or marly deposits of the old lake basins. One of the latter deposits, located a little over a mile west of La Paz, northeast quarter of section 30 (35 N., 2 E.), is owned by the Sandusky Portland Cement Co., and furnishes the clay ingredient for all the Portland cement made at their large plant at Syracuse, Ind., 30 miles to the east. This plant is operated by the wet process, marl forming the carbonate of lime ingredient. The B. & O. Railway runs through the center of the clay deposit owned by the company, the clay being shipped over that line to the plant. At the main pit the stripping of soil and sand runs about two and a half feet in thickness and the clay from 12 to 20 feet. Beneath the clay is eight inches of gravel and hardpan, which overlies a stratum of sand. The clay is an exceed-

ingly fine-grained, soft, gritless, silty material of two colors, one forming the upper bed, five to nine feet in thickness, being buff; the other, or lower bed, 7 to 11 feet thick, being grayish-blue. Analyses of the two, kindly furnished me by M. M. Smith, chemist at the plant, show their composition to be as follows:

*Analyses of Silty Clays Used in the Making of Portland Cement at
Syracuse, Indiana.*

	<i>Upper or Buff.</i>	<i>Lower or Gray Blue.</i>
Silica (SiO_2)	70.22	55.50
Alumina (Al_2O_3)	13.95	11.95
Ferric oxide (Fe_2O_3)	4.97	4.37
Calcium oxide (CaO)	1.94	8.30
Magnesium oxide (MgO)	2.15	5.51
Sulphuric anhydride (SO_3) .....	.20	1.20
Potassium oxide (K_2O)	2.24	.85
Sodium oxide (Na_2O}) .....	.57	.19
Carbon dioxide (CO_2), water, etc.	4.18	12.45
Total	100.42	100.32

The analyses show the blue-gray clay to belong to the marly group, while the composition of the upper or buff clay is very similar to that of some of the surface loess clays of southern Indiana.*

Regarding the high percentage of magnesia in the lower clay, Mr. Smith wrote as follows:

"The 5.51 per cent. of magnesium oxide, as shown in the analysis of the blue clay, is somewhat high, providing that the marl with which it is mixed is relatively high. Our marl, however, very seldom runs over 2 per cent. magnesium oxide, and the average would probably be closer to 1 per cent. Inasmuch as we use approximately one part clay to four parts marl for our mix, you can readily see that using marl and clay maximum in magnesium oxide, our finished cement would only contain about 4 per cent. Recent investigation has shown that 5 per cent. magnesium oxide is not deleterious to the quality of Portland cement, the hydraulic constituents, of course, being in correct proportions, properly mixed and burned. However, our method of digging the clay at the pit is such that we receive here at the works about an equal amount of blue and yellow clay, pretty well mixed. An average of the two analyses would show 3.83 per

* See pp. 23, 302.

cent. magnesium oxide, which would figure about 3 per cent. in the finished cement, or well within the 5 per cent. limit. We find the clay in every way suitable for the purpose for which it is used."

This clay deposit is located at the highest point on the B. & O. Railway between Syracuse and Chicago, and it was found necessary, when digging the well which supplied water at the pit, to go down 110 feet. Between the property and La Paz, however, there is a marshy tract of land, and without doubt the clay is on the site of an ancient lake or swamp.

At the present time the clay is excavated and loaded into railway cars by a steam shovel, from 200 to 300 tons being loaded each day. By this means the clay costs about 35 cents per ton delivered at the Syracuse plant. Five men are employed in digging it, their average daily wage being \$1.50. About 45,000 tons were used in 1904.

Deposits of similar marly clays will doubtless be found beneath the sites of former lakes in many parts of Marshall County. The surface clays of the county are at present burned into clay wares at Teegarden, Argos and at a point seven miles north of Plymouth. At the latter place J. W. Thomas & Son make brick, drain tile and hollow block from a "black gumbo surface underlain with blue clay, the two together being from 4 to 10 feet thick." The output is mostly drain tile, which, in 1904, were sold at the following prices:

Price List of Drain Tile in Marshall County.

	<i>Per Rod.</i>	<i>Per 1,000 Feet.</i>
3 inch.....	\$0 16	\$10 00
3½ inch.....	20	12 50
4 inch.....	22	15 00
5 inch.....	32	20 00
6 inch.....	40	25 00
7 inch.....	51	32 00
8 inch.....	64	40 00
9 inch.....	80	50 00
10 inch.....	1 04	65 00
12 inch.....	1 44	90 00

At Teegarden a blue clay, six to eight feet deep, is used in making the same class of products as at the Thomas yard, while at Argos the upper three feet of a bed of bluish clay, said to be 60 feet thick, is used for drain tile.

STARKE COUNTY.

Starke County lies west of Marshall, in the second tier of counties south of Michigan, and in the third east of Illinois. Its eastern border is 18 miles and its southern border 24 miles in length. Nine miles west of its northeastern corner the Kankakee River intervenes between it and Laporte County, and, flowing southwesterly, forms the remainder of the northern and all but five miles of the western boundary. Yellow River, flowing west through the center of the county, and Bogus River and Pine Creek, north through the southwestern fourth, empty into the Kankakee. Bass Lake, formerly known as Cedar Lake, lies in the southeastern part, and is 2.23 square miles in area, with an average depth of about 20 feet.

The county is well supplied with railways, four passing entirely across it, while one, the Panhandle Division of the Pennsylvania System, cuts its southwestern corner. Those crossing it from east to west are the Pittsburgh, Fort Wayne & Chicago, across the northern third; the New York, Chicago & St. Louis (Nickel Plate), across the center, and the Chicago & Erie across the southern third. The Indiana, Illinois & Iowa ("Three I") enters the extreme southwestern corner of the county and leaves the northeastern, thus cutting diagonally its full length.

The county has an area of 314 square miles, the surface of which is diversified by marsh, wet prairie, dry prairie and sand ridge, the latter predominating. More than half the area is covered to a depth of 2 to 15 feet by the fine-grained buff sand so characteristic of all the region adjacent to the Kankakee on the south. Experience has proven that this sandy soil, if properly cultivated, will produce excellent melons, cucumbers, sugar beets, berries, grapes, etc. Where ploughed deep and fertilized it also yields good crops of corn, oats and potatoes. Within the past ten years colonies of frugal, industrious Germans and Swedes have bought, at a low price, large areas of this once despised land and are making a good living from it. They utilize all fertilizers produced on the farm; they haul muck from the lowlands and mix it with the sand; they plough deeply each season, and by these means and others are proving the land of far greater productive power than it was ever believed to be.

Many thousand acres of the marsh land in the northern half of the county have been recently drained, and where a few years ago the waters were waist deep the year round bountiful crops of corn are now produced. That the county is rapidly coming to the front agriculturally is proven by the growth of Knox, the county seat, where a number of fine business blocks have been erected since 1897, and where a \$90,000 court house was finished in 1898.

Not an outcrop of rock occurs in the county. The only bores known to have pierced the thick mantle of drift are at Knox and North Judson, in both of which stratified rock was found about 200 feet below the surface.

Beneath the sand, the prairie-sod and marsh bottoms of Starke County there is everywhere the fine-grained, ash-blue boulder clay which covers the entire area of northwestern Indiana. In many places this comes close to the surface. At the north end of Bass Lake it is nine and a half feet thick beneath two to ten feet of sand. Along the east border of the county a number of wells have been put down to depths of 30 to 100 feet, mainly through yellow and blue clays. One of the deepest, on the land of J. Pette, in section 24 (32 N., 1 W.), disclosed the following drift constituents:

Section of Well in Eastern Starke County.

	<i>Feet.</i>
1. Yellow clay	12
2. Blue clay	16
3. Gray sand	52
4. Blue clay	4
5. Cemented sand and gravel.....	15

A mile north a well on the land of David Fetter passed through a 12-foot layer of blue clay five feet below the surface.

Several brick factories have, in the past, been started in Starke County, but usually by some one inexperienced in clay working and without capital. As a result, they were failures, and, after a few kilns were burned, they were abandoned. One of these factories was located in section 5 (32 N., 2 W.), a mile and three-quarters east of Toto, a station on the "Three I" Railway. A record of the well on the former yard is as follows:

Section of Well East of Toto.

	<i>Feet.</i>
1. Sand	2
2. Yellow clay	4
3. Blue clay	38
4. Sand	8
5. Blue clay	23
6. Sand	5

The clay used was that from stratum No. 2, mixed with a foot or two of that from No. 3. It contained quite a percentage of disseminated carbonate of lime, but no lime pebbles. The mixture burned red and, from samples of brick and tile left on the yard, produced wares of good quality. Wood, costing but \$1.25 per cord, was used for fuel, and the brick were sold at the yard for \$6.00 per thousand. They were made on a Penfield brick and tile machine and dried in an open yard. The parties claimed that the location was too distant from Knox, about five miles to the northeast, where the brick were mostly sold, and that the demand was too limited to continue the business.

On the land of Isaac R. Bascom, northeast quarter of section 1 (32 N., 3 W.), one-third of a mile west of Toto, a reddish-yellow clay comes to the surface near the right of way of the "Three I" Railway. This clay has been proven by tests in three factories to be well fitted for the making of brick and tile. It contains some pebbles, and a disintegrator and crusher would have to be used. This location is one of the best in the county for a clay factory for brick and tile, as a switch could be put into the plant with but little expense. Water in abundance can be obtained at all seasons from the Bass Lake outlet, which passes through the deposit. A factory started at this place could supply, at a low rate, all the brick needed in the towns of Starke County along the "Three I" Railway, and at the same time the constantly increasing local demand for tile among the farmers. At present these clay products are mostly shipped into both Knox and North Judson from other counties.

The only clay-working plant at present in existence in the county is that of Marquis & Keller, located three and a half miles west of Knox. A bluish-gray surface clay is used to a depth of five feet, after stripping about six inches of surface. The main output is drain tile, made on a Wallace machine, dried in sheds

and burned in a round, down-draft kiln. On account of an overflow of Yellow River in the spring of 1904, which flooded the plant and rendered the roads leading thereto impassable, it was not operated during that season.

Three miles south of Knox, on the land of John Lindstrand, northwest quarter of section 3 (23 N., 2 W.), occurs a deposit of clay suitable for brick and tile. It covers 40 or more acres, and comes to within less than a foot of the surface.

On the line between Marshall and Starke counties, section 36 (33 N., 1 W.), a brick and tile factory was in operation for a number of years, but has been recently abandoned on account of its distance from a town of any size. I did not visit this point, but was informed that the wares gave good satisfaction wherever used.

Nine miles west of Knox, on the land of Fred. Surma, northeast of 33 (33 N., 3 W.), a number of kilns of brick have been burned to supply a local demand, but no permanent factory has been started. Just across Yellow River, one-third of a mile north of the court house at Knox, several kilns were also made a number of years ago from an alluvial deposit, but the clay is of poor quality and in no place more than two feet in thickness, and overlies a bed of sand. It was used only because no better deposit was thought to occur in the county.

These constitute all the points, so far as could be ascertained, at which clay suitable for brick or tile comes close to the surface in Starke County. By stripping the sand the blue clay will be everywhere found, but ordinary brick have not, as yet, been made from it. Custom has established the idea that brick and tile should be of a red color, and since the blue clay burns yellow, it is wrongly considered to be useless for such wares. At any one of two or three of the points mentioned a man with a practical knowledge of clay working and possessed of energy could establish a combined brick and tile factory on a paying basis, since a county which is advancing as rapidly as Starke should by all means support at least one such factory within her bounds.

JASPER COUNTY.

Jasper County lies east of Newton and south of the Kankakee River, which forms its northern boundary. The Iroquois River, with its tributaries, Pickamink River and Carpenter's Creek, drains about three-fourths of its area. The county contains about 565 square miles of surface, which is very diversified in character. The northern half is, for the most part, sandy, with intervening low prairies, marshes and ridges, and knolls covered with scrub oak timber.

The marshes and wet prairies, when drained, produce excellent crops, and comprise the best land in this section of the county. In Berkley, Gillam and Walker townships is one tract of 33,000 acres, owned by Benjamin J. Gifford, of Kankakee, Illinois, a large portion of which has been drained since 1893. Immense crops of oats and corn are produced, and a thriving farming community now exists where, but a few years ago, only the wild duck and the muskrat flourished. The southwestern part of the county is a gently rolling prairie of black, loamy soil.

"In the northern part of the county the drift deposits are 75 to 200 feet in depth, but in the central and southern portions, although the altitude is as great as in the northern portion, the drift deposits are generally quite thin, there being often only a coating of sand, 10 to 20 feet in depth."

The clays of Jasper County are the characteristic drift and marly clays of Northwestern Indiana. The best grade of clay noted is located two miles north of Rensselaer, in section 7 (29 N., 6 W.), and is utilized for drain tile by Alter & Wolfe.* A prominent ridge rises 30 or more feet above the plain on which Rensselaer stands, passes east and west through this and adjoining sections, and contains the deposit of clay. At the pit near the summit of this ridge the section exposed was as follows:

Section at Clay Pit of Alter & Wolfe.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil	0	8
2. Yellow clay with occasional pebbles.....	3	6
3. Grayish blue clay.....	10	0

A well close to the pit pierced the blue clay to a depth of 126 feet before striking a water supply in gravel. In the making of

* See statistical table at end of paper.

tile but a few inches containing the roots of grass are stripped, and the clay from top to bottom of the pit is mixed in the proportion in which it occurs. This mixture is soaked for a day or two and then passed through a Potts disintegrator and made into tile on a New Departure machine. The mixture burns pinkish on account of the presence of the top stratum. By itself the lower stratum burns to a cream color.

The grayish blue clay is very hard and has to be dug with a pick, as a spade will not penetrate it. It is fine-grained and very stiff and tenacious. It makes a firm, smooth tile of excellent quality, for which the demand has lately been greater than the supply. With proper weathering and tempering it could be made into hollow brick, flue linings, fireproofing and many similar products, but contains too high a percentage of fluxes for paving brick, sewer pipe or other vitrified wares. The deposit of this clay comes close to the surface over several sections, both east and west of the point where it is worked, and its quality is such as to merit a more extended use.

Just west of Rensselaer, on the north half of section 25 (29 N., 7 W.), John Kohler & Son made brick and tile for several years. The section exposed at their clay pit was as follows:

Section at Old Clay Pit of Kohler & Son.

	<i>Feet.</i>	<i>Inches.</i>
1. Soil and surface clay.....	1	6
2. Tough, plastic bluish clay.....	4	0
3. Bluish pebbly clay.....	1	6
4. Bluish clay free from pebbles.....	9	0

Stratum No. 1 was used for making brick and No. 2 for tile. Were it not for the heavy stripping the lower stratum, No. 4, could be used for brick. It has been tested, and forms a very hard, whitish product. Clays of the same quality as those of this yard occur close to the surface over an area one and a quarter miles long and half a mile wide west of Rensselaer.

On the land of John T. Randall, near the postoffice of Pleasant Grove, ten miles northeast of Rensselaer, drain tile has been made for 18 years. The material used is the ordinary fine-grained blue clay, mixed with about one foot of black soil and two feet of red clay. The blue clay at this point is 50 feet in thickness.

Wares made of it alone air-crack in drying. Many unburned tile which had been exposed to a strong wind and had cracked were scattered about the yard. Some trouble is also experienced with lime pebbles in the red clay. The owner claimed that below the depth exposed the blue clay became of the same character as that north of Rensselaer.

Good clay for drain tile, fireproofing, etc., also occurs on the land of John English, northeast quarter of section 9 (29 N., 6 W.), and on that of Murray Bros., northeast quarter of section 10 (29 N., 6 W.).

On the land of Dr. W. W. Hartsell, two miles west and one mile south of Rensselaer, a well section showed 4 feet of soil and loam and 30 feet of clay, the latter being very sticky, fine-grained and free from grit or pebble. Just as it comes from the bed it can be formed by the hands into shallow vessels, which will hold water until it evaporates. It can be burned into solid fireproofing, flue linings, foundation brick, etc., but will probably need some tempering with sand on account of its great tenaciousness.

A similar clay to that on the Hartsell farm is exposed in a large dredged ditch in Milroy Township. This ditch is a mile in length, extending from the center of section 10 to the center of section 15 (28 north, 6 west). The upper portion of the clay lies from two to four feet below the surface, but its thickness has never been ascertained. When damp it can be cut into ribbon as thin as a knife blade and a yard long. When dry it is very hard and tough. It is probably too far distant from a railway for utilization.

At Remington, on the P., C., C. & St. L. Railway, near the southern edge of the county, a tough blue clay, eight to ten feet thick, is made into tile by Greene & Bowman. It lies immediately below eight inches of soil, part of which is mixed with it when used. It contains numerous pebbles, which must be crushed or thrown out by a disintegrator, but otherwise is well suited for tile-making.

This comprises all the exposures of clay which I was enabled to visit in Jasper County. The blue clay, which is the more common, probably underlies the entire county, but only in the vicinity of Rensselaer was it found of a quality suitable for making other wares than drain tile.

PULASKI COUNTY.

This county, comprising 437 square miles, is located in the northwestern part of the State, lying east of Jasper and south of Starke counties. The greater part of its surface is a broad plain, which occupies a portion of the divide between Kankakee and Tippecanoe rivers, yet there is no dividing ridge, and large tracts in the northwestern part of the county can be drained with equal readiness to either stream. The fall of the surface of the ground toward both streams is so slight and the surface conditions are such that a vast expenditure of money in drainage has been required to render tillage possible. That portion of the county east of the Tippecanoe River is much better drained.

The transportation facilities of the county are but fair. The Michigan City Division of the Monon (C., I. & L.) runs north and south across the western third. The P., C., C. & St. L. crosses from northwest to southeast, a little east of the center, while the Chicago & Erie touches the northeastern corner. A large portion of the western two-thirds is, therefore, distant from railways.

In the flat prairie or plain district of the northwestern portion the surface wells, 20 to 40 feet deep, penetrate sand only. In the southwestern part of the county the drift deposits are generally thin, the wells entering the Niagara limestone at 10 to 20 feet. At Winamac, the county seat, the wells often reach a depth of 50 to 60 feet, passing through 10 to 25 feet of sand or a sandy clay loam, below which is a bed of blue clay extending to the water-bearing gravel.

The only commercially available clays of the county are the surface drift clays, and these are worked only at Winamac and Francisville.* At the former place a "blue clay, five feet thick, is used for brick and drain tile, after stripping 8 to 12 inches of black loam." At Francisville a similar clay six feet thick is used for drain tile only.

FULTON COUNTY.

Fulton County is located near the center of the northern half of Indiana. It is in the third tier of counties south of the Michigan-Indiana line, and is bounded on the north by Marshall, on

*See statistical table at end of paper.

the east by Kosciusko, Wabash and Miami, on the south by Miami and Cass and on the west by Pulaski County. In outline it is quite irregular, the south and east sides being dovetailed in with some of the townships of the adjoining counties in a very peculiar manner. The total area of the county is 382 square miles.

The surface is everywhere covered with drift, and is very diversified. The Maxinkuckee moraine covers the northern third of the county, while the eastern and southeastern portions are covered by the western slope of a bulky moraine formed by the Erie lobe. These two moraines connect in the northeastern part of the county to form the great Erie-Saginaw interlobate moraine, which passes northeastward into Michigan through the northeastern part of Indiana. The thickness of the drift is known only at Rochester, where it ranges between 155 and 245 feet, and at Kewanna, where it is between 167 and 208 feet.

The county is well supplied with railways, three passing entirely through it. These are: The Michigan City Division of the Lake Erie & Western, which passes north and south through the central portion; the Chicago & Erie, which enters the county near De Long, in the northwest corner, and leaves at the extreme southeastern corner, thus passing diagonally across its bounds, and the Michigan Division of the Vandalia, which runs north and south a few miles east of the western boundary, passing through Kewanna and crossing the C. & E. at De Long.

The county lies on the southeastern extremity of the prairies, which cover a great part of the northwestern counties of the State. These prairies lose themselves in the oak openings and disappear almost entirely after the center of Fulton is reached. Nearly 15 per cent. of the surface is prairie, the remainder being pretty equally divided between oak openings, or barrens, and heavy timbered lands. The surface is level, as a rule, but broken into considerable hills in Henry township, in the eastern, and in Richland, in the northern part.

West of Rochester there is much marsh land, with sandy ridges, which is imperfectly drained by Mud Creek and other streams and ditches, into the Tippecanoe.

The surface drift clays of the county are the only ones suitable for manufacturing purposes. They are at present used only

at Fulton, Akron and Metz.* At the former place, after stripping six inches of black soil, the underlying surface clay is used to a depth of 18 to 24 inches in making drain tile. At Akron and Metz the thickness of stripping and clay is about the same, brick and tile being the products made.

Four miles north of the center of Rochester, on the north half of the southwest quarter of section 28 (Michigan road land) is a thick bed of drift clay, covering 25 to 30 acres, which, for a number of years prior to 1890, was used for ordinary building brick and drain tile. The upper six feet of the deposit is a siliceous red clay of good quality for the wares for which it was used. Below this is a stratum of whitish or dove-colored marly clay, 7 to 14 feet in thickness, very fine-grained, wholly free from grit and weathering into small quadrangular pieces. An analysis of this clay, made by Dr. Noyes, showed its composition to be as follows:

Analysis of Silty Clay from Four Miles North of Rochester.

Silica (SiO_2)	45.12
Titanium oxide (TiO_2).....	.45
Alumina (Al_2O_3)	6.84
Water combined	2.43
<hr/>	
Clay base and sand.....	54.84
Ferric oxide (Fe_2O_3).....	5.92
Ferrous oxide (FeO).....	1.38
Lime (CaO)	15.63
Magnesia (MgO)	4.88
Potash (K_2O)	2.28
Soda (Na_2O}) .....	.74
<hr/>	
Fluxes	30.83
Carbon dioxide (CO_2).....	14.95
<hr/>	
Total	100.62

The analysis shows the clay to be lower in alumina and higher in lime than most of the marly clays of Northern Indiana. It could be burned into terra cotta lumber, but for other products would doubtless have to be mixed with another clay higher in alumina.

Samples of a yellow surface drift clay, secured by Hon. G. W. Holman, of Rochester, from a point a half mile south of Akron,

*See statistical table at end of paper.

north half of southeast quarter of section 24 (30 N., 5 E.), were analyzed by T. W. Smith, of this city, and the chemical composition found to be:

Analysis of Yellow Drift Clay from Fulton County.

Silica (SiO_2)	71.01
Alumina (Al_2O_3)	19.02
Titanium oxide (TiO_2).....	.13
Water combined	5.64
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Clay base and sand.....	95.80
Ferric oxide (Fe_2O_3).....	1.35
Ferrous oxide (FeO).....	.62
Lime (CaO)52
Magnesia (MgO)	1.05
Soda (Na_2O}) .....	.30
Potash (K_2O}) .....	.15
<hr/>	
Fluxes	3.99
Organic matter .....	.20
<hr/>	
Total	99.99

The analysis shows the clay to be very pure for one of drift origin. It will withstand high heat, but the percentage of fluxes is too low for it to be utilized for vitrified products. It will make a good dry pressed-front brick. The percentage of silica is rather high for Portland cement making, but otherwise it would serve well for that purpose. The deposit is just south of the Chicago & Erie Railway, and covers about 50 acres to a depth of six to seven feet.

WHITLEY COUNTY.

This county comprises 338 square miles, and is bounded on the north by Noble, on the east by Allen, on the south by Huntington and Wabash and on the west by Wabash and Kosciusko counties. The railway facilities of the county are fair. The Pittsburgh, Fort Wayne & Chicago passes from northwest to southeast through the central portion; the Eel River Division of the Vandalia from northeast to southwest diagonally across the county, and the New York, Chicago & St. Louis (Nickel Plate) from east to west through the northern part of the southern tier of townships. The surface of the county lies between 787 and

948 feet above tide, the lowest point being near Collamer and the highest near Larwill.

The entire area of the county is overlain with drift, the thickness of which is known in but two places, viz., at Columbia City, where it is 224 feet, and at Larwill, seven miles west, where it is 365 feet in thickness. That portion of the surface lying east and south of Eel River is flat or slightly rolling, being a part of the great level plain of east-central Indiana, though occasional knolls and ridges of drift, especially in Cleveland township, give it some diversity. North and west of Eel River the surface is much more irregular, and contains many deep, elongated valleys, with sharp, winding ridges intervening. The region drained by Blue River, comprising the northeastern third of the county, is less broken, but is still typically morainic in character.

The drift of the county is, for the most part, clayey in nature, there being but limited areas in which sand or gravel is found at the surface or at slight depths. To a depth of 50 or 60 feet it is usually a compact yellow or blue clay. At Columbia City the wells penetrate 30 to 40 feet of such clay before reaching gravel, while at Cherubusco they run from 50 to 80 feet through the same material.

The only workable clays of the county are the surface yellow deposits. These are utilized for brick and tile at Columbia City, Collins and Cherubusco.* At the first-named place "a black and yellow clay, from two to three feet thick," is used without stripping for drain tile, hollow block and building brick. One and a half miles east, at the yard of Sherwood & Son, "clay of a blue color," five feet thick, is used for drain tile and brick, after removing four or five inches of top soil. At Cherubusco, after stripping the sod, a blue and yellow clay mixed is used to a depth of four feet for making drain tile. Five miles north of Columbia City from three to four feet of a "blue, waxy clay" is used for tile, after removing about one foot of "black top soil," while at Collins a mixture of yellow and blue surface clay is used for both brick and tile.

*See statistical table at end of paper.

ALLEN COUNTY.

Allen, the largest county in Indiana, comprises 664 square miles, lying next to the Ohio State line, south of Noble and DeKalb and east of Huntington and Whitley counties. Transportation facilities are excellent, the county being crossed east and west by the Wabash, the Pittsburgh, Fort Wayne & Chicago and the New York, Chicago & St. Louis railways; north and south by the Grand Rapids and Indiana, the Fort Wayne, Cincinnati & Louisville and the Fort Wayne Branch of the Lake Shore & Michigan Southern.

The city of Fort Wayne (population 50,000), the county seat, and the third city in the State, is situated three miles west of the center of the county, at the junction of its three principal rivers—the St. Joseph, St. Mary's and Maumee. Its site is at the beginning of the portage from the Maumee to the Wabash Rivers, and its occupation as a French trading post dates back to 1680.

"The greater part of the county has a level surface, though there are two well-defined morainic belts which pass through it. The St. Mary's moraine enters in the southeastern part and follows the northeast border of the St. Mary's River to Fort Wayne. It then finds its continuation northward on the east side of the St. Joseph River. The Wabash moraine enters the county near Zanesville, in its southwest corner, and passes thence northward to the old lake outlet near Aboit. North from the outlet its course is northeastward along the northwest side of the St. Joseph River. There is a narrow plain in southern Allen County between these two moraines, but in northern Allen County they are separated only by the valley of the St. Joseph River. A plain in the northwestern part of the county extends beyond its limits into Dekalb and Whitley counties. The plain in the eastern part of the county, formerly covered by the glacial lake which discharged southwestward to the Wabash, has a very smooth surface, with only an occasional low ridge of sand or bar of gravel formed by the lake waters.

"In the southern half of the county the thickness of the drift is very much less than in the northern half, though probably averaging not less than 75 feet. At Fort Wayne it is 60 to 125 feet or more. Near the north border of the county the drift exceeds

200 feet, two borings having reached that depth without entering rock. In the south part of the county it is in places but 20 or 30 feet."*

The greater part of the drift penetrated by surface wells is made up of yellow and blue clays. At the courthouse yard in Fort Wayne a well passed through 88 feet of drift, most of which was clay. In section 1, Milan Township, in the northeast part of the county, a flowing well on the land of B. A. Rupert shows the drift strata to be arranged as follows:

Section of Flowing Well on Rupert Farm.

	<i>Feet.</i>
1. Yellow clay	7
2. Blue clay with gravel.....	20
3. Marly clay	5
4. Quicksand	1
5. Water bearing gravel.....	3

At the county infirmary wells 25 to 35 feet deep pass through clay, after penetrating a few feet of surface sand. Just east of the village of New Haven a well shows the following section:

Section of Well East of New Haven.

	<i>Feet.</i>
1. Beach sand and gravel.....	9
2. Blue clay	33
3. Gravel	3
4. Blue clay and hardpan.....	23
5. Small boulders and gravel.....	5

In the southern and southwestern portions of the county the wells pass through 20 to 30 feet of clay before reaching water gravel.

The only clays of the county which can be utilized are the yellow and blue ones of drift origin. These are burned into ordinary brick and drain tile at a number of places.† At the yard of the Fort Wayne Brick & Tile Co. from 18 to 30 inches of surface clay are used without stripping for making soft mud building brick. The output in 1904 was 4,000,000, valued at \$25,000. At Wallen, in the northwest part of the county, a blue clay, two and a half feet thick, is used without stripping for making drain tile.

*Leverett. Wells of Northern Indiana, 1899, 48.

†See statistical table at end of paper.

Brick and tile are made at Woodburn from a bed of surface clay three and a half feet thick, which is used from the grass roots down.

* * *

This completes the list of counties of the State, as taken up in the order of their geological areas. As before stated, attention has been called only to the larger and more available deposits of commercial clays found within their bounds. The presence in large quantities of the raw materials suitable for making every kind of clay product used in Indiana, with the exception of some of the finer clays used in the better grades of terra cotta, encaustic tile and chinaware, has been shown. The clays for the cheaper and vastly more used products, millions of dollars' worth of which are annually imported into the State, are lying undeveloped, and surrounded in many instances with the fuel necessary for their burning. With these resources present, why should Indiana be behind the other States in clay manufacturing? Why should she make only 4.35 per cent. of the total value of the clay products made in the United States, when Ohio and Illinois, with no more extensive or better beds of the raw material, make, respectively, 19 and 8.5 per cent.?

The people of this State are not awake to the opportunities and advantages in their midst. The majority of the clay industries which have started up at Brazil, Montezuma, Terre Haute and elsewhere within the past ten years are owned by parties outside of Indiana, and the profits accruing, which are large, go mostly without her bounds. As was well said by the superintendent of one of the largest of these factories (himself an Ohio man and the factory owned by Ohio capitalists): "The people of Indiana don't seem to know a good thing when they have it. They wait for outsiders to come in, gain possession of it and make it known to them, and then, too late, they realize its importance." Home factories should be erected, should be protected, should be patronized, for in such a way only can the future wealth and welfare of the State be increased and plentiful labor provided for her workmen.

Analyses of Carboniferous Shales.

	1		2		3		4		5		6		7		8		9	
	Total.	Insoluble.	Total.	Insoluble.	Total.	Insoluble.	Total.	Insoluble.	Total.	Insoluble.	Total.	Insoluble.	Total.	Insoluble.	Total.	Insoluble.	Total.	Insoluble.
Silica (SiO ₂).....	56.62	.....	59.55	35.98	59.77	31.87	58.83	29.16	59.02	26.13	65.78	43.25	46.07	26.33	56.32	23.47	61.46	33.98
Titanium oxide (TiO ₂).....	21.63	.....	1.00	.....	20.60	1.66	22.34	1.81	20.93	.66	14.70	2.54	1.19	1.19	1.07	1.20	1.20	.....
Alumina (Al ₂ O ₃).....	6.53	.....	16.21	.39	4.53	.....	5.22	.....	7.59	.....	4.98	.....	24.22	2.97	24.34	2.98	16.54	1.72
Water (combined).....	.....	.....	5.62	.....	.....	.....	.....	.....	.....	.....	.....	.....	9.76	.....	.....	5.09	.....	.....
Clay base and sand.....	84.78	.....	82.38	.....	85.70	.....	87.09	.....	88.64	.....	86.55	.....	81.24	.....	88.06	.....	84.29	.....
Ferric oxide (Fe ₂ O ₃).....	7.08	.....	2.18	.....	2.22	.....	5.13	.....	4.45	.....	8.03	.....	9.65	.....	5.60	.....	8.77	.....
Ferrous oxide (FeO).....	7.13	.....	7.13	.....	3.70	.....	1.44	.....	1.46	.....	.34	.....	.34	.....	.34	.....	3.71	.....
Lime (CaO).....	1.11	.....	1.48	.....	1.44	.....	1.49	.....	1.51	.....	.54	.....	.19	.....	.21	.....	1.69	.....
Magnesia (MgO).....	1.41	.....	1.48	.....	1.96	.....	1.56	.....	1.66	.....	1.42	.....	1.31	.....	1.31	.....	1.81	.....
Potash (K ₂ O).....	3.14	.....	2.81	.06	3.10	.88	4.16	.14	2.92	.31	2.82	1.13	1.66	.....	2.86	.....	3.28	.82
Soda (Na ₂ O).....	.48	.....	.28	.....	.85	.....	.63	.....	.41	.....	.97	.....	2.76	.....	2.54	.....	1.09	.....
Fluxes.....	13.22	.....	14.73	.....	12.49	.....	13.43	.....	11.51	.....	13.78	.....	15.91	.....	11.88	.....	14.32	.....
Carbon dioxide (CO ₂).....	.....	.....	3.15	.....	.90	.....	.....	.....	.....	.....	.26	.....	2.87	.....	.....	.....	1.45	.....
Totals.....	98.01	.....	100.26	36.42	99.09	34.41	100.52	31.11	100.15	27.10	100.59	46.92	100.62	29.30	99.94	26.40	100.06	36.52

Rational Analyses of Above Shales.

Quartz.....	34.61	.....	26.04	.....	22.81	.....	22.82	.....	34.34	.....	15.31	.....	15.31	.....	13.19	.....	27.94	.....
Feldspathic detritus.....	1.81	.....	8.37	.....	8.30	.....	8.30	.....	12.58	.....	13.39	.....	13.39	.....	13.21	.....	8.56	.....
Ferrous carbonate.....	8.61	.....	2.37	.....	2.37	.....	2.08	.....	.50	.....	.54	.....	.54	.....	.....	.....	3.82	.....
Magnesium carbonate.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Clay substance.....	54.97	.....	63.22	.....	63.22	.....	68.89	.....	72.90	.....	52.58	.....	70.72	.....	75.54	.....	59.68	.....

Composition of Clay Substances of Above Shales.

Silica (SiO ₂).....	42.40	.....	44.06	.....	42.71	.....	44.83	.....	42.38	.....	27.91	.....	27.91	.....	44.53	.....	45.94	.....
Titanium oxide (TiO ₂).....	1.80	.....	1.26	.....	1.02	.....	1.50	.....	1.88	.....	1.68	.....	1.68	.....	1.46	.....	2.00	.....
Alumina (Al ₂ O ₃).....	28.46	.....	29.91	.....	29.55	.....	27.68	.....	23.04	.....	30.04	.....	30.04	.....	29.11	.....	24.63	.....
Ferric oxide (Fe ₂ O ₃).....	3.92	.....	3.51	.....	7.39	.....	6.06	.....	16.10	.....	13.64	.....	13.64	.....	7.61	.....	6.30	.....
Ferrous oxide (FeO).....	3.56	.....	3.74	.....	2.08	.....	2.13	.....	.32	.....	.32	.....	.48	.....	.32	.....	2.24	.....
Lime (CaO).....	1.35	.....	1.01	.....	.71	.....	.70	.....	1.01	.....	.26	.....	.26	.....	.42	.....	1.03	.....
Magnesia (MgO).....	2.84	.....	3.13	.....	2.25	.....	2.28	.....	2.22	.....	1.85	.....	1.85	.....	.73	.....	3.03	.....
Potash (K ₂ O).....	5.06	.....	4.90	.....	5.86	.....	3.98	.....	3.18	.....	2.34	.....	2.34	.....	3.87	.....	4.44	.....
Soda (Na ₂ O).....	.....	.....	1.34	.....	5.91	.....	.58	.....	1.82	.....	3.90	.....	3.90	.....	3.18	.....	1.82	.....
Water (H ₂ O).....	10.11	.....	7.15	.....	7.52	.....	10.53	.....	9.37	.....	13.80	.....	13.80	.....	8.60	.....	8.50	.....

Analyses of Carboniferous Shales.

	10		11		12		13		14		15		16		17		18	
	Total.	Insoluble.	Total.	Insoluble.	Total.	Insoluble.	Total.	Insoluble.	Total.	Insoluble.	Total.	Insoluble.	Total.	Insoluble.	Total.	Insoluble.	Total.	Insoluble.
Silica (SiO ₂).....	61.05	27.10	55.31	31.67	64.05	.....	59.04	33.85	57.60	40.47	62.04	43.58	65.87	46.10	56.68	35.53	53.26	30.17
Titanium oxide (TiO ₂).....	1.20	.....	1.15	.....	1.00	.....	18.93	1.23	24.74	9.78	18.49	3.70	14.56	2.63	20.33	1.62	1.06	.....
Alumina (Al ₂ O ₃).....	21.46	.35	22.46	5.62	16.00	.....	6.98	.....	8.14	.....	6.50	.....	14.56	.....	6.54	.....	25.77	.46
Water (combined).....	6.94	.....	7.48	.....	3.79	.....	.....	.....	.....	.....	.....	.....	4.59	.....	.....	.....	7.00	.....
Clay base and sand.....	90.05	.....	86.40	.....	84.84	.....	86.15	.....	91.37	.....	87.33	.....	86.22	.....	84.45	.....	87.08	.....
Ferric oxide (Fe ₂ O ₃).....	5.57	.....	7.18	.....	.89	.....	1.62	.....	.15	.....	7.54	.....	6.22	.....	4.35	.....	3.32	.....
Ferrous oxide (FeO).....	.71	.....	.23	.....	6.85	.....	5.01	.....	2.41	.....	.06	.....	1.37	.....	3.69	.....	3.82	.....
Lime (CaO).....	.25	.....	.66	.....	.42	.....	.70	.....	.16	.....	.39	.....	.39	.....	.37	.....	1.90	.....
Magnesia (MgO).....	.75	.....	.93	.....	2.00	.....	1.80	.....	1.20	.....	.91	.....	1.54	.....	2.04	.....	2.54	.....
Potash (K ₂ O).....	2.84	.04	2.08	.....	2.59	.....	3.66	.99	3.40	.....	.93	.....	2.66	1.21	3.15	.94	2.54	.25
Soda (Na ₂ O).....	.30	.....	2.06	.....	1.19	.....	.81	.....	.99	.....	2.04	.....	1.31	.....	.63	.....	.44	.....
Fluxes.....	9.87	.....	13.11	.....	12.94	.....	13.75	.....	8.86	.....	12.64	.....	13.50	.....	14.43	.....	12.34	.....
Carbon dioxide (CO ₂).....	.....	.....	1.24	.....	2.68	.....	2.22	.....	.....	.....	.....	.....	.....	.....	.47	.....	1.10	.....
Totals.....	100.52	27.49	100.75	37.29	100.46	.....	101.12	35.87	100.22	50.25	99.97	47.28	99.72	49.94	99.35	38.09	100.52	30.96

Rational Analyses of Above Shales.

Quartz.....	25.87	.....	11.91	.....	.....	.....	29.83	.....	6.14	.....	30.80	.....	36.87	.....	29.85	.....	28.66	.....
Redpathitic detritus.....	1.62	.....	25.38	.....	.....	.....	6.54	.....	44.11	.....	16.68	.....	13.07	.....	8.24	.....	2.32	.....
Ferrous carbonate.....	.....	.....	.37	.....	.....	.....	1.52	.....	.....	.....	.....	.....	.....	.....	1.23	.....	2.90	.....
Magnesium carbonate.....	.....	.....	.....	.....	.....	.....	2.96	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Clay substance.....	72.51	.....	63.46	.....	.....	.....	59.65	.....	49.75	.....	52.69	.....	50.06	.....	60.68	.....	66.12	.....

Composition of Clay Substances of Above Shales.

Silica (SiO ₂).....	46.47	.....	37.25	.....	.....	.....	42.78	.....	34.44	.....	35.03	.....	39.71	.....	35.83	.....	34.54	.....
Titanium oxide (TiO ₂).....	1.64	.....	1.81	.....	.....	.....	1.15	.....	1.78	.....	2.47	.....	2.21	.....	1.52	.....	1.58	.....
Alumina (Al ₂ O ₃).....	28.90	.....	26.53	.....	.....	.....	29.12	.....	30.07	.....	28.07	.....	24.15	.....	31.69	.....	37.96	.....
Ferric oxide (Fe ₂ O ₃).....	7.92	.....	11.31	.....	.....	.....	2.47	.....	.31	.....	14.51	.....	12.50	.....	7.37	.....	4.98	.....
Ferrous oxide (FeO).....	.97	.....	.36	.....	.....	.....	8.24	.....	4.31	.....	.11	.....	2.76	.....	8.37	.....	3.03	.....
Lime (CaO).....	.34	.....	1.04	.....	.....	.....	.....	.....	1.41	.....	.30	.....	.79	.....	.97	.....	.48	.....
Magnesia (MgO).....	.95	.....	1.46	.....	.....	.....	.64	.....	2.41	.....	1.73	.....	.48	.....	3.46	.....	2.96	.....
Potash (K ₂ O).....	3.20	.....	3.23	.....	.....	.....	4.30	.....	6.83	.....	1.77	.....	2.92	.....	8.74	.....	3.30	.....
Soda (Na ₂ O).....	.40	.....	3.24	.....	.....	.....	1.33	.....	1.99	.....	3.87	.....	2.64	.....	1.07	.....	.66	.....
Water (H ₂ O).....	9.80	.....	11.78	.....	.....	.....	9.97	.....	16.36	.....	12.34	.....	9.22	.....	11.08	.....	10.50	.....

REMARKS ON ANALYSES OF CARBONIFEROUS SHALES.

The foregoing analyses of Carboniferous Shales, with the exception of No. 1, were all made for this Department. In each case they were based on an average sample, dried at 135° C. The parts marked "insoluble" were found to be insoluble in acids and sodium carbonate.

In the rational analyses, the quartz was determined by subtracting 3.51 times the insoluble alumina from the insoluble silica. The remainder of the insoluble portion was counted as feldspathic detritus. The general method of analysis followed was that given in Wagner's "Chemical Technology."

No. 1. Average of ten analyses of shales used in the manufacture of paving brick and sewer pipe in the State of Ohio. Adopted as the standard for this report. Taken from Prof. Edward Orton, Jr.'s "Report on the Clay Working Industries of Ohio." (Vol. VII, Ohio Geol. Surv., 1893, 133.)

No. 2. Mixture of shale and surface clay, as used by the Wash Clay Co., Veedersburg, Fountain County, in the making of paving block. Noyes, Chemist. See p. 82.

No. 3. Shale No. 2, from land of Mecca Coal and Mining Co., Mecca, Parke County. Noyes, Chemist. See p. 112.

No. 4. Shale No. 9, from land of Mecca Coal and Mining Co., Mecca, Parke County. Noyes, Chemist. See p. 112.

No. 5. Shale No. 13, from land of Mecca Coal and Mining Co., Mecca, Parke County. Noyes, Chemist. See p. 112.

No. 6. Shale used by the Cayuga Brick & Coal Co., Cayuga, Vermillion County, in the making of dry pressed front brick. Noyes, Chemist. See p. 130.

No. 7. Shale No. 6, from the Burns & Hancock land, West Montezuma, Vermillion County. Lyons, Chemist. See p. 136.

No. 8. Shale No. 11, from the Burns & Hancock land, West Montezuma, Vermillion County. Lyons, Chemist. See p. 136.

No. 9. Mixed shales, used by the Clinton Paving Brick Co., Clinton, Vermillion County, in the making of paving block. Noyes, Chemist. See p. 148.

No. 10. Shale from the old Casto, or Thorp farm, Sugar Creek Township, Vigo County. Noyes, Chemist. See p. 165.

No. 11. Shale No. 8, from above coal IV, mine No. 1, of the

Island Coal Co., near Linton, Greene County. Lyons, Chemist. See p. 238.

No. 12. Shale from above coal VII, at Prospect Hill mine, near Vincennes, Knox County. Noyes, Chemist. See p. 256.

No. 13. Shale from Larkin farm, near Loogootee, Martin County. Noyes, Chemist. See p. 277.

No. 14. Shale or "clod" from above worked vein of coal at Buckskin mine, near Buckskin, Gibson County. Lyons, Chemist. See p. 300.

No. 15. Shale from near Southern Railway shops, at Princeton, Gibson County. Lyons, Chemist. See p. 303.

No. 16. Mixture of shale and surface clay, used by the Evansville Pressed Brick Co., Evansville, Vanderburgh County, in the making of paving brick. Noyes, Chemist. See p. 312.

No. 17. Shale from cut on Cannelton Branch of the Southern Railway, a mile and a quarter southeast of Lincoln City, Spencer County. Noyes, Chemist. See p. 327.

No. 18. Shale from above coal II, on the land of the American Cannel Coal Co., near Cannelton, Perry County. Noyes, Chemist. See p. 336.

Analyses of Coal Measure Under-Clays.

	1		2		3		4		5		6		7		8	
	Total.	Insoluble.	Total.	Insoluble.	Total.	Insoluble.	Total.	Insoluble.	Total.	Insoluble.	Total.	Insoluble.	Total.	Insoluble.	Total.	Insoluble.
Silica (SiO ₂)	68.46	50.63	67.82	52.63	71.91	62.33	64.46	20.28	63.00	27.05	67.66	55.35	66.52	52.23	53.91	16.13
Titanium oxide (TiO ₂)	1.49	1.10	1.10	.....	.....	.....	1.20	.....	1.10	.....	1.01	.....	1.02	.....	1.00	.....
Alumina (Al ₂ O ₃)	16.08	3.72	13.60	3.97	17.62	.44	25.71	.17	23.57	.21	19.97	7.71	20.13	7.19	26.18	.27
Water (combined)	7.04	.....	9.72	.....	5.37	.....	8.50	.....	6.45	.....	5.86	.....	6.13	.....	7.99	.....
Clay base and sand	93.07	.....	92.24	.....	95.21	.....	89.87	.....	94.12	.....	94.59	.....	93.79	.....	89.68	.....
Ferric oxide (Fe ₂ O ₃)	1.92	.....	4.04	.....	2.55	.....	5.51	.....	1.87	.....	.72	.....	1.03	.....	3.39	.....
Ferrous oxide (FeO)	.06	.....	.45	.....	.40	.....	.91	.....	.46	.....	.....	.....	.....	.....	1.25	.....
Lime (CaO)	.99	.....	.57	.....	.43	.....	.24	.....	.44	.....	.48	.....	.83	.....	.30	.....
Magnesia (MgO)	.05	.....	.44	.....	.17	.....	.83	.....	.89	.....	.....	.....	.69	.....	.95	.04
Potash (K ₂ O)	1.31	.....	1.68	.....	2.00	.....	2.68	.07	2.40	.05	1.75	.....	3.05	.....	3.60	.....
Soda (Na ₂ O)	2.40	.....	1.18	.....	.15	.28	.33	.....	.29	.....	2.29	.....	.57	.....	.44	.....
Fluxes	6.73	.....	8.36	.....	5.70	.....	10.50	.....	6.35	.....	5.83	.....	6.17	.....	9.93	.....
Carbon dioxide (CO ₂)	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.25	.....
Totals	99.80	54.35	100.60	56.60	100.91	63.05	100.37	20.52	100.47	27.31	100.42	63.05	99.96	59.47	99.86	16.43

Rational Analyses of Above Under-Clays.

Quartz	37.58	38.70	60.80	19.69	26.31	28.29	27.05	15.17
Feldspathic detritus	16.87	17.90	2.24	.83	1.00	34.77	32.52	1.26
Ferrous carbonate	.....	.....	.....	.....	.....	.....	.....	.....
Magnesium carbonate	.....	.....	.....	.....	.....	.....	.....	.....
Clay substance	45.35	44.00	37.87½	79.48	72.69	36.94	40.43	88.09

Composition of Clay Substances of Above Under-Clays.

Silica (SiO ₂)	99.31	34.55	.....	42.79	49.15	32.93	35.22	45.66
Titanium oxide (TiO ₂)	3.28	2.50	.....	1.50	1.50	2.71	2.52	1.92
Alumina (Al ₂ O ₃)	27.25	21.88	6.25	31.95	31.93	32.82	31.98	31.24
Ferric oxide (Fe ₂ O ₃)	4.23	9.18	6.89	6.89	2.54	1.93	2.52	4.08
Ferrous oxide (FeO)	1.13	1.02	.....	1.14	.63	.....	.....	1.51
Lime (CaO)	2.18	1.29	.....	1.04	.61	1.26	2.05	.97
Magnesia (MgO)	2.11	1.00	.....	1.04	1.21	1.58	1.70	.86
Potash (K ₂ O)	2.88	3.82	.....	3.85	3.23	4.68	7.54	4.30
Soda (Na ₂ O)	5.28	2.68	.....	4.1	.38	6.12	1.40	.53
Water (H ₂ O)	15.52	22.09	.....	10.63	8.82	15.96	15.16	9.63

Analyzes of Coal Measure Under-Clays.

	9		10		11		12		13		14		15		16		17
	Total.	Insoluble.	Total.	Insoluble.	Total.	Insoluble.	Total.	Insoluble.	Total.	Insoluble.	Total.	Insoluble.	Total.	Insoluble.	Total.	Insoluble.	Total.
Silica (SiO ₂).....	55.09	22.48	83.44	76.90	61.05	44.86	75.57	54.45	73.82	64.20	69.23	41.22	65.25	.....	57.57	24.00	58.78
Titanium oxide (TiO ₂).....	1.20	.....	1.29	.....	1.10	.....	1.85	.....	1.60	.....	1.50	.....	1.10	.....	1.10	.....	94
Alumina (Al ₂ O ₃).....	20.76	.45	10.86	8.71	5.80	.....	13.97	3.88	14.46	.74	18.97	.86	17.30	.....	21.70	.30	26.47
Water (combined).....	7.01	.....	3.15	.....	8.88	.....	4.47	.....	3.82	.....	5.46	.....	5.40	.....	6.78	.....	9.96
Clay base and sand.....	84.06	.....	98.24	.....	94.58	.....	94.86	.....	92.70	.....	95.16	.....	87.95	.....	87.15	.....	96.15
Ferric oxide (Fe ₂ O ₃).....	3.00	.....	.27	.....	2.61	.....	1.47	.....	.83	.....	1.57	.....	2.30	.....	2.26	.....	1.22
Ferrous oxide (FeO).....	4.01	.....	.28	.....	1.42	.....	.95	.....	1.95	.....	.55	.....	.50	.....	4.11	.....	.59
Lime (CaO).....	1.51	.....	.36	.....	.29	.....	.71	.....	.30	.....	.12	.....	.20	.....	.32	.....	.32
Magnesia (MgO).....	1.18	.....	.14	.....	.58	.....	1.71	.....	.58	.10	.36	.....	.05	.....	1.12	.24	.99
Potash (K ₂ O).....	2.36	.....	.03	.....	.51	.....	1.77	.....	2.07	.....	.33	.....	.98	.....	2.16	.....	.....
Soda (Na ₂ O).....	.34	.....	.71	.....	.40	.....	.46	.....	.30	.....	.....	.....	.....	.....	.33	.....	.....
Fluxes.....	12.40	.....	1.79	.....	5.81	.....	5.36	.....	6.03	.....	5.20	.....	5.54	.....	10.30	.....	3.12
Carbon dioxide (CO ₂), etc.....	3.04	.....	.....	.....	.....	.....	.....	.....	.94	.....	.....	.....	6.50	.....	1.73	.....	.....
Totals.....	99.50	22.93	100.08	85.61	100.39	50.66	100.22	58.83	99.67	65.04	100.36	41.63	99.99	.....	99.18	29.54	99.27

Rational Analyses of Above Under-Clays.

Quartz.....	20.90	46.33	24.51	40.83	61.60	39.36	27.96
Pelaspatic detritus.....	2.03	39.28	26.15	17.50	3.44	1.67	1.96
Ferrous carbonate.....	6.46	.....	.....	.....	2.48	.....	3.65
Magnesium carbonate.....	1.13	.....	.....	.....	.....	.....	.....
Clay substance.....	69.48	14.39	49.34	41.67	32.46	58.37	66.81

Composition of Clay Substances of Above Under-Clays.

Silica (SiO ₂).....	47.28	45.44	38.91	50.68	23.94	47.70	43.29
Titanium oxide (TiO ₂).....	1.74	8.96	2.22	2.08	1.87	2.55	1.67
Alumina (Al ₂ O ₃).....	29.44	11.46	29.86	24.21	42.66	31.67	32.04
Ferric oxide (Fe ₂ O ₃).....	4.35	1.87	5.28	3.52	2.58	2.67	3.43
Ferrous oxide (FeO).....	1.94	1.94	2.87	3.52	1.28	2.93	3.32
Lime (CaO).....	2.19	2.50	.58	2.28	1.93	.21	3.46
Magnesia (MgO).....	.92	.92	1.11	1.70	1.90	.42	1.70
Potash (K ₂ O).....	3.42	.20	1.08	4.24	6.13	3.75	2.91
Soda (Na ₂ O).....	4.83	4.83	.81	1.10	6.18	5.51	5.60
Water (H ₂ O).....	10.16	21.83	17.99	10.72	11.86	9.30	10.27

REMARKS ON ANALYSES OF COAL MEASURE UNDER-CLAYS.

The analyses of the foregoing under-clays, with the exception of No. 17, were made for this Department. The methods were essentially the same as those used in the analyses of the Carboniferous Shales.

No. 1. Under-clay suitable for stoneware, from land of Minnick & Hoagland, near Stone Bluff, Fountain County. Lyons, Chemist. See p. 78.

No. 2. Under-clay from land of Frank Landers, near Stone Bluff, Fountain County. Lyons, Chemist. See p. 79.

No. 3. Under-clay from beneath coal V, on land of John R. Teegarden, near Kingman, Fountain County. Noyes, Chemist. See p. 87.

No. 4. Under-clay No. 12, from land of the Mecca Coal & Mining Co., Mecca, Parke County. Noyes, Chemist. See p. 114.

No. 5. Under-clay No. 20, from land of Mecca Coal & Mining Co., Mecca, Parke County. Noyes, Chemist. See p. 114.

No. 6. Under-clay No. 24, from beneath coal IV, on land of Mecca Coal & Mining Co., Mecca, Parke County. Lyons, Chemist. See p. 114.

No. 7. Under-clay No. 27, from beneath coal III, on land of Mecca Coal & Mining Co., Mecca, Parke County. Lyons, Chemist. See p. 114.

No. 8. Under-clay from beneath coal VI, on land of W. W. Ray, near Coxville, Parke County. Noyes, Chemist. See p. 123.

No. 9. Under-clay from mine of Cayuga Brick & Coal Co., Cayuga, Vermillion County. Noyes, Chemist. See p. 131.

No. 10. Under-clay No. 10 from land of Burns & Hancock, West Montezuma, Vermillion County. Lyons, Chemist. See p. 137.

No. 11. Under-clay No. 10, from land of Jackson Bros., between West Montezuma and Newport, Vermillion County. Lyons, Chemist. See p. 140.

No. 12. Potters' clay from beneath coal VI, from land of Chas. Coopridge, near Clay City, Clay County. Lyons, Chemist. See p. 210.

No. 13. Under-clay from beneath coal III, on Crance land, three and a half miles south of Worthington, Greene County. Noyes, Chemist. See p. 235.

No. 14. Potters' clay from pit of Bockting Bros., Huntingburg, Dubois County. Noyes, Chemist. See p. 285.

No. 15. Potters' clay from land of Chris. Fuchs, near Huntingburg, Dubois County. Smith, Chemist. See p. 289.

No. 16. Under-clay from beneath coal II, in mine of the American Cannel Coal Co., near Cannelton, Perry County. Noyes, Chemist. See p. 335.

No. 17. Ballou under-clay from Muskingum County, Ohio, used as a bond for flint clays in forming high grade refractory materials. Lord, Chemist.

Analyses of Knobstone Shales.

	1		2		3		4		5		6		7		8		9		10	
	Total.	Insoluble.	Total.	Insoluble.	Total.	Insoluble.	Total.	Insoluble.	Total.	Insoluble.	Total.	Insoluble.	Total.	Insoluble.	Total.	Insoluble.	Total.	Insoluble.	Total.	Insoluble.
Silica (SiO ₂).....	68.14	60.16	70.84	32.25	70.60	68.44	59.64	30.22	59.95	56.38	64.59	54.61	63.88	60.64	58.22	34.72	74.43	68.90	68.90	
Titanium oxide (TiO ₂).....	1.33	0.90	1.16		1.38	1.05	1.05		1.12		1.30		0.91		1.15		1.30	1.30	1.30	
Alumina (Al ₂ O ₃).....	16.03	9.90	14.73	1.76	13.68	3.36	19.14	1.61	18.65	1.86	16.87	2.48	17.85	9.32	19.63	4.66	6.86	17.20	17.20	
Water (combined).....	3.86		3.32		3.19		4.36		4.54		3.71		4.99		6.61		2.24	3.97	3.97	
Clay base and sand.....	80.41		89.07		88.11		84.19		84.26		84.97		87.63		85.61		83.55	90.07	90.07	
Ferric oxide (Fe ₂ O ₃).....	4.54		4.82		2.83		3.90		4.87		5.97		5.38		5.88		6.53	5.05	5.05	
Ferrous oxide (FeO).....	47		1.38		3.46		2.26		3.94		1.69		3.8		1.96		1.32	2.10	2.10	
Lime (CaO).....	3.7		1.36		5.0		2.31		2.18		1.16		1.47		2.10		1.36	1.36	1.36	
Magnesia (MgO).....	3.80		3.15	.75	2.70	1.48	3.53	.60	3.57	1.01	4.24	1.53	3.58		3.68		2.40	1.85	1.85	
Potash (K ₂ O).....	1.50		1.42		1.60		.90		.75		.87		1.29		.68		1.86	1.00	1.00	
Soda (Na ₂ O).....																				
Fluxes.....	10.58		11.13		11.35		14.49		15.08		13.80		12.50		14.54		15.50	9.90	9.90	
Carbon dioxide (CO ₂).....			.21		.51		.35		.28		.43						.76			
Totals.....	99.99	69.35	100.41	34.76	99.97	73.28	90.03	32.43	99.62	59.25	99.29	56.62	100.13	59.96	100.15	39.38	99.86	99.97	99.97	

Rational Analyses of Above Shales.

Quartz.....	26.15		28.07		56.65		25.57		49.85		45.88		17.93		18.37					
Feldspathic detritus.....	43.70		8.29		16.83		6.86		9.40		12.74		42.08		21.01					
Calcium carbonate.....			.48		1.07		.87		.62		.29									
Magnesium carbonate.....					.06		.67				.57									
Clay substance.....	30.15		65.17		25.57		60.90		40.13		39.81		40.04		50.62					

Composition of Clay Substances of Above Shales.

Silica (SiO ₂).....	26.46		59.21		8.46				8.97				38.06		38.76					
Titanium oxide (TiO ₂).....	4.57		1.38		1.68				2.83				2.27		1.90					
Alumina (Al ₂ O ₃).....	21.02		19.90		41.23				42.23				21.80		24.68					
Ferric oxide (Fe ₂ O ₃).....	15.06				9.12				12.25				13.43		9.69					
Ferrous oxide (FeO).....			7.40		13.94				8.40											
Lime (CaO).....	1.55		.17										.94		3.21					
Magnesia (MgO).....	1.89		2.09		1.80				5.49				3.67		3.46					
Potash (K ₂ O).....	12.60		3.68		5.02				6.44				9.94		6.49					
Soda (Na ₂ O).....	4.97		2.18		6.26				1.96				3.22		1.12					
Water (H ₂ O).....	12.80		5.09		12.49				11.43				12.46		10.90					

REMARKS ON ANALYSES OF KNOBSTONE SHALES.

All the analyses given were made for this Department.

No. 1. Shale from near ice house at Attica, Fountain County. Lyons, Chemist. See p. 72.

No. 2. Shale from land of Arthur Hadley, two miles south of Danville, Hendricks County. Noyes, Chemist. See p. 350.

No. 3. Shale from land of Branch & Son, near Martinsville, Morgan County. Noyes, Chemist. See p. 355.

No. 4. Shale from Blue Lick, Jackson County. Used as the clay ingredient of Portland cement at the factory of the Lehigh Portland Cement Co., Mitchell, Lawrence County. Noyes, Chemist. See p. 366.

No. 5. Shale from land of Matthews and Chrisler, northeast of Blue Lick, Jackson County. Noyes, Chemist. See p. 367.

No. 6. Shale from land of D. M. Hughes, near Medora, Jackson County. Noyes, Chemist. See p. 368.

No. 7. Shale used at the Goetz dry pressed brick factory, one mile west of New Albany, Floyd County. Lyons, Chemist. See p. 376.

No. 8. Shale from cut of the Indianapolis Southern Railway, on the land of Jas. McLarey, nine miles northeast of Bloomington, Monroe County. Lyons, Chemist. See p. 382.

No. 9. Shale from land of William Fee, two miles northeast of Bloomington, Monroe County. Noyes, Chemist. See p. 383.

No. 10. Shale from land of W. H. Gregory, near Heltonville, Lawrence County. Smith, Chemist.

Analyses of Surface Drift, Alluvial, Silty and Loess Clays.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Total.	Total.	Total.	Total.	Total.	Total.	Total.	Total.	Total.	Total.	Total.	Total.	Total.	Total.	Total.
Silica (SiO ₂)	66.84	66.11	71.20	73.97	49.51	67.15	72.56	79.99	67.76	50.56	50.37	53.02	50.47	45.12	71.01
Titanium oxide (TiO ₂)	13.64	13.73	18.56	12.33	14.73	13.96	10.44	8.66	13.66	13.11	9.63	10.72	14.45	6.46	19.02
Alumina (Al ₂ O ₃)	4.22	6.34	6.30	3.16	3.59	3.25	4.54	3.55	7.10	2.76	1.50	2.21	3.14	2.43	5.54
Water (combined)	84.70	86.23	96.94	90.37	66.70	84.36	87.35	92.20	80.44	67.43	62.45	67.25	67.83	54.84	95.80
Clay base and sand	9.40	5.35	1.94	3.87	4.66	6.84	7.45	3.31	5.09	2.98	2.10	2.54	2.44	5.02	1.35
Ferric oxide (Fe ₂ O ₃)	1.36	1.57	1.15	.....	.....	.....	43	.....	46	2.32	2.05	2.32	2.52	1.33	.....
Ferrous oxide (FeO)	.....	.....	.....	.....	.....	1.23	32	57	54	7.57	10.26	8.38	8.17	15.63	32
Lime (CaO)	.....	.....	.....	.....	.....	1.34	1.09	1.77	51	6.06	6.35	5.28	5.22	4.88	1.06
Magnesia (MgO)	Trace	.....	.....	.....	.....	.....	2.05	1.93	3.26	3.74	3.04	3.25	3.70	2.23	.....
Potash (K ₂ O)	84	2.11	.....	.....	.....	.....	73	53	51	70	.....	56	73	74	50
Soda (Na ₂ O)	3.34	1.15	1.25	4.23	2.40	3.33	.....	.....	.....	.....	.....	.....	.....	.....	.....
Fluxes	14.74	12.06	3.73	9.64	20.87	13.12	12.57	7.41	10.77	22.67	24.50	22.53	22.78	30.83	3.99
Carbon dioxide (CO ₂), etc.	.....	.....	.....	.....	10.72	3.00	.....	33	.....	9.62	12.50	10.48	9.90	14.95	20
Totals	98.44	98.29	100.67	100.01	100.29	100.48	100.42	99.94	100.21	99.72	99.45	100.26	100.41	100.62	99.99

REMARKS ON ANALYSES OF SURFACE DRIFT, ALLUVIAL, SILTY
AND LOESS CLAYS.

The foregoing analyses were, with the exception of No. 6, all made for this Department, by the chemists mentioned in the following notes.

No. 1. Surface drift clay from near Rockville, Parke County. Smith, Chemist. See p. 124.

No. 2. Alluvial clay from low lands on the Wabash River near Terre Haute, Vigo County. Used extensively for the making of ordinary soft mud brick. Noyes, Chemist. See p. 170.

No. 3. Surface loess clay from near Southern Railway shops, Princeton, Gibson County. Lyons, Chemist. See p. 302.

No. 4. Surface drift clay, used for ordinary brick making at Mooresville, Morgan County. Lyons, Chemist. See p. 356.

No. 5. Surface silty or marly clay, from land of Mrs. Abrilla Merriman, three miles south of Martinsville, Morgan County. Lyons, Chemist. See p. 357.

No. 6. Red residual surface clay from Indiana University campus, Bloomington, Monroe County. Kibler, Chemist. See p. 384.

No. 7. Residual surface clay from above the oölitic limestone at the quarry of the National Stone Co., four miles south of Bloomington, Monroe County. Noyes, Chemist. See p. 384.

No. 8. Residual surface clay from above the Mitchell limestone, nine miles south of Bloomington, Monroe County. Noyes, Chemist. See p. 384.

No. 9. Surface drift clay from Jessup land near Richmond, Wayne County. Used in the making of flowerpots and kindred earthenwares. Lyons, Chemist. See p. 437.

No. 10. Silty or marly clay from Hobart, Lake County. Used extensively in the making of terra cotta lumber, fireproofing, dry pressed front brick and kindred products. Noyes, Chemist. See p. 455.

No. 11. Silty or marly clay from pit of old brick yard at Garden City, Porter County. Noyes, Chemist. See p. 459.

No. 12. Silty or marly clay from pit at brick yard of P. E. Anderson, near Chesterton, Porter County. Noyes, Chemist. See p. 462.

No. 13. Silty or marly clay from pit at brickyard of Roeske Bros., near Michigan City, Laporte County. Noyes, Chemist. See p. 464.

No. 14. Silty or marly clay from a point four miles north of Rochester, Fulton County. Noyes, Chemist. See p. 497.

No. 15. Yellow drift clay from a point a half mile south of Akron, Fulton County. Smith, Chemist. See p. 498.

SECTION IV. THE CLAY-WORKING INDUSTRIES OF INDIANA.

The clay-working industry in Indiana may be said to be yet in its infancy. During the ten years from 1894 to 1903, inclusive, it had a steady and gradual growth. The annual value of the clay products of the State increased in that time from \$3,135,569 to \$5,694,625. However, the relative rank of the State as a clay-producing center was, at the end of the decade, the same as at the beginning, it holding sixth position among other States, both in 1894 and 1903. The following table shows the rank held by the first ten States in the value of products of clay from 1894 to 1903, also the value of the output and per cent. of total production of each of the ten in 1903:*

RANK OF THE TEN LEADING CLAY-PRODUCING STATES IN VALUE OF CLAY PRODUCTS, 1894-1903.

STATE.	YEAR.										Value in 1903.	Per cent. of Total Production in 1903.
	1894	1895	1896	1897	1898	1899	1900	1901	1902	1903		
Ohio.....	1	1	1	1	1	1	1	1	1	1	\$25,208,128	19.25
Pennsylvania.....	3	2	2	2	2	2	2	2	2	2	18,847,324	14.37
New Jersey.....	5	5	5	3	3	3	3	3	3	3	13,416,389	10.24
Illinois.....	2	3	4	5	4	5	4	4	4	4	11,190,797	8.54
New York.....	4	4	3	4	5	4	5	5	5	5	9,208,352	7.03
Indiana.....	6	6	7	6	6	6	6	7	6	6	5,694,625	4.35
Missouri.....	7	7	6	7	7	7	7	6	7	7	5,661,607	4.32
Iowa.....	8	9	9	9	8	8	8	8	8	8	3,093,403	2.36
California.....	16	10	21	21	12	12	14	11	11	9	2,831,543	2.16
West Virginia.....	21	17	16	13	13	13	9	9	9	10	2,558,560	1.95

The table shows that Indiana and Missouri are very close in the value of the annual output of clay products, and that Missouri outranked Indiana in 1896 and 1901.

The following table, extracted from the Annual Report of the Mineral Resources of the United States for 1903,† shows the value of the clay products of Indiana for the five years 1900-1904:

* Adapted from "Statistics of the Clay Working Industry, in the United States in 1903." In Mineral Resources U. S., 1903.

† The figures for 1904 were gathered by the writer for this report.

Clay Products of Indiana, 1900-1904.

PRODUCT.	1900.	1901.	1902.	1903.	1904.
Brick:					
Common—					
Quantity.....	274,383,000	315,966,000	305,233,000	294,890,000	294,409,500
Value.....	\$1,391,873	\$1,624,133	\$1,710,385	\$1,697,190	\$1,725,162
Average per M.....	\$5.08	\$5.14	\$5.60	\$5.76	\$5.86
Pressed—					
Quantity.....	19,084,000	27,293,000	24,866,000	24,742,000	29,606,000
Value.....	\$172,752	\$234,775	\$215,202	\$232,487	\$240,670
Average per M.....	\$9.05	\$8.60	\$8.65	\$9.36	\$8.03
Vitrified—					
Quantity.....	30,326,000	31,468,000	45,933,000	47,864,000	49,305,000
Value.....	\$331,276	\$320,221	\$441,494	\$482,967	\$545,721
Average per M.....	\$10.92	\$10.18	\$9.61	\$10.09	\$11.06
Fancy or ornamental, value....	\$7,310	\$8,160	\$10,398		
Fire, value.....	\$40,976	\$51,526	\$66,725	\$115,526	\$128,760
Drain tile, value.....	\$674,002	\$772,241	\$807,516	\$1,014,706	\$1,023,571
Sewer pipe, value.....	\$279,719	\$253,626	\$311,223	\$363,212	\$417,260
Fireproofing, value.....	\$116,381	\$91,081	\$342,854		\$165,000
Tile, not drain, value.....	\$343,386	\$478,130	\$579,596	\$163,082	\$450,000
Earthenware and stoneware, value.....	\$48,544	\$54,371	\$28,780	\$73,160	\$88,780
Miscellaneous*, value.....	\$450,732	\$578,190	\$769,260	\$1,252,236	\$1,300,500
Total value.....	\$3,858,350	\$1,466,454	\$5,283,733	\$5,694,625	\$6,085,424

* Included in miscellaneous are ornamental terra cotta, yellow and Rockingham ware, C. C. white graniteware, sanitary ware, porcelain electrical wares, glass pots, hollow building block, conduits, and all products not otherwise classified.

Although the above statistical tables show a steady growth in the annual value of clay products of Indiana, yet, taking into consideration the clay resources, the cheapness of fuel and the transportation facilities of the State, the output is not what it should be. There is room for five times as many clay factories as now exist without overcrowding or overdoing the business, for the number and variety of clay products is increasing at a marvelous rate, while the growth of the country and the rapid disappearance of the forests is ever widening the demand and opening up new markets.

With no better or more abundant clays than Indiana possesses, Ohio far outranks our State in the value of her clay wares, and easily holds first place among the clay manufacturing States of the Union. This is largely due to the energies of the two Ortons—Edward, Sr., and Jr.—who, foreseeing the coming increase in the use of clay for manufacturing purposes, carefully investigated the clays of that State and published extensive papers calling the attention of capitalists to their value.

The clay industries of Indiana may be grouped, according to the kinds of ware they manufacture, into the following classes:

- I. The Manufacture of Paving Material.
- II. The Manufacture of Sewer Pipe and Kindred Hollow Wares.
- III. The Manufacture of Refractory Products.
- IV. The Manufacture of Pottery and Allied Products.
- V. The Manufacture of Dry Pressed Brick, Structural Terre Cotta and Encaustic Tile.
- VI. The Manufacture of Ordinary Building Brick and Drain Tile.
- VII. The Production of Clay for Shipment.

Each of these will be taken up and mention made of the processes involved, and such statistics will also be given in tabular form as could be obtained from the owners of the factories.

I. THE MANUFACTURE OF PAVING MATERIAL.

CHOICE OF CLAYS.—The two most valuable properties which a paving brick must possess are those of *vitrification*, or the power to withstand the absorption of water, and *toughness*, or the ability to withstand abrasion and wear. Parties who are thinking of erecting a plant for the making of pavers must choose a clay which, when properly burned, will possess in a high degree the above properties, else their money will be wasted in a worse than useless project.

Among the clays found in Indiana and mentioned in the previous sections, those which are best adapted for the making of paving material are the Carboniferous and Knobstone shales. Before a plant be located at any deposit, full tests should be made and the clay found therein proven to be refractory enough to stand up under the heat required to bring about vitrification, and yet to contain fluxes sufficient to cause such vitrification to begin at a temperature considerably below that at which softening and loss of shape takes place. The only fully reliable test which can be made is the taking of a large quantity of the shale or other clay to some factory and there making it into brick and burning them under conditions as nearly as possible like those which will be present after the plant is erected. Such a test is far more valuable than the one commonly in vogue of sending a keg or two of the clay to some dealer in brick machinery and having a dozen

or twenty brick made therefrom. Such brick show only the *best products obtainable* from the clay, and are no criterion of what it will do under the normal and average conditions existing in a large plant. *They are made to sell brick machinery*, and all possible precautions are taken to have each one absolutely without a flaw.

While the average composition of the best clays for paving brick and other purposes is well known, too much reliance must not be placed upon the chemical analysis of a clay in question, and no plant should be erected with it as the sole existing test. It serves well as a preliminary test to determine the *possible* usefulness of the clay for the purposes wanted, as from it the refractoriness can be readily judged, but it is no criterion of the toughness and other essential properties which the burned product must possess.

The clays found in Indiana which can be used for making paving brick may be conveniently grouped under the following heads:

1. Carboniferous and Knobstone shales.
2. The more plastic under-clays of the coal seams.
3. Recent sedimentary clays of the river bottoms.

The question naturally arises, which of these is best suited for the purpose in hand? This can best be answered from the experiences of the past and from the results of a long series of tests made under uniform conditions. When the paving brick industry was first started in the central States the larger portion of the brick were made of the under or so-called "fire-clays" of the Coal Measures. These have been gradually supplanted by the shales, as actual experience has shown that the brick made from the latter are more lasting, wear more uniformly, and in general give far better satisfaction. Moreover, the shales are far more abundant, more easily mined, and, while requiring the expenditure of more power to prepare them for use, are more easily vitrified than the under-clays.

No facilities being at hand for the proper testing of a large number of clays in order to prove the relative value for vitrified brick of the different kinds of materials mentioned above, I have availed myself of the results of a series of tests made by Prof. Edward Orton, Jr., at the State University of Ohio, on clays of

the same nature from that State. These results were first published in the seventh volume of the Ohio Geological Survey, and afterwards, in a modified form, in "The Clay Worker." From the latter publication the following extract is taken:

"The shales or bricks whose chief component is shale, and whose color is red or dark, were grouped together and were represented by 23 samples. Fifteen varieties of under-clay bricks, or those in which under-clay is the largest constituent, and whose color is light, were grouped together. Four varieties of shale and under-clay mixtures, in about equal proportions, were grouped together, and three varieties, composed of Ohio River sedimentary clays exclusively, constitute the last class. The average results of the tests of these four classes were as follows:

	No. of Samples.	Absorp- tion.	Rattling.	Crushing, sq. inch.	Rank.
Shales.....	23	1.17	17.61	7,307	1
Under-clays.....	15	1.62	17.32	6,876	2
Mixture of shales and under-clays	4	1.44	18.72	5,788	3
River clays.....	3	1.36	19.02	4,605	4

"In this table the shales have the advantage over their competitors, showing the first rank in absorption and crushing and a close second in rattling. The under-clays are indicated as being slightly tougher than the shales, but considerably more porous. Also, the same tendency is again more strikingly illustrated in the table of bricks having the highest average excellence in the test. Taking the ten highest averages, represented by 16 factories, it is found that 13 are shale brick, against three under-clay brick, showing that the best material of the State is 80 per cent. of it made of shale clay."

This series of tests, taken in connection with the experience of the past, proves conclusively that the shales are the best suited of the three classes of material mentioned for the making of high-grade paving brick.

LOCATING THE PLANT.—Other conditions besides the quality of the clay must be taken into consideration in choosing the site for the location of a paving brick or other clay factory. Among the most important of these are the quantity of clay, the amount of labor necessary to secure it and its nearness to fuel, railway facilities and markets for the manufactured product.

The quantity of clay used in a large paving brick factory in the course of a single year is much greater than is usually supposed. Taking into consideration the shrinkage in burning, each thousand brick of ordinary size, $2\frac{1}{2} \times 4 \times 8\frac{1}{2}$ inches, will require an average of two and a half cubic yards of clay, and standard paving block, $9 \times 3\frac{1}{4} \times 4$ inches, will require nearly one-half as much more. If the clay be ten feet in thickness, and 40,000 brick of ordinary size be made each day, about one and two-thirds acres of the clay will be used each year. If block are made, about two and a half acres will be used. The quantity of clay available must, therefore, be carefully determined before the site of the factory is chosen.

The question of stripping becomes an important one in the securing of large amounts of clay, and its cost must always be considered in choosing a site for a plant. Many deposits of shale and fire-clay, otherwise valuable, are rendered comparatively worthless by the great amount of material overlying them. In many cases much of this material can be mixed with that of the main deposit without injury to the product. This should not be done, however, until numerous tests have proven beyond doubt its suitability for the purpose.

Where the number of factories is large and competition causes the output to be sold at a close margin, the cost of fuel becomes an important factor in the making of clay products. This should always be considered, and, other things being equal, the plant located as near as possible to a cheap and practically inexhaustible fuel supply. In these days of protracted drouths the future water supply is another factor to be considered, for large quantities are used for steam purposes and for moistening the clay in the wet pan or pug mill.

The question of transportation is also a most important one in the choosing of a site for a clay factory. If possible, the location should be such that first-class railway facilities can be readily obtained and sidetracks laid into the yard. The finished product can then be loaded directly into the cars without preliminary hauling in wagons. Other conveniences, however, should not be sacrificed to gain such railway facilities. It is much better to locate the plant in close proximity to the supply of clay and then build a single switch to it than to erect it by the main line of a railway a mile or two from the deposit. The latter plan has,

unfortunately, been followed by three of the six factories in this State, necessitating much expense in the hauling or shipping of the raw material. Where possible, it is better to locate close to the junction point of two or more railways. This eliminates largely the chance of an arbitrary advance in shipping rates, and provides direct communication with a greater number of markets.

Those paving brick factories which are located near cities of sufficient size to use brick for paving purposes have many advantages. If their output is of such a quality as to meet all requirements it can be laid down at a good profit in such a home market at a less cost than any outside competitor can furnish it after paying freight rates. In addition to this saving of transportation, there is always a sale in such a city for the second-grade brick for use in sidewalks, gutters, foundations, etc. These "seconds" are also beginning to be put to quite extensive use as a rock-face building material. From 10 to 25 per cent. of the total output of the average factory is composed of such "seconds." These are soft brick, or those overburnt, cracked or twisted in burning. In the course of a year they amount to several hundred thousands, perhaps millions, and unless sold for some price, accumulate until they become a nuisance in the yard. All sums which they bring may be counted as clear gain, and the cost of production of those unsold must be added to the debit side of the year's account.

SECURING THE CLAY.—There are two methods of removing the clay from the earth; one by stripping the overburden and quarrying from the surface, and one by running in a drift and mining underground. Which of these methods is employed depends on the thickness and character of the stripping, the thickness of the clay and its position in the hill. Sometimes both methods are used together, that is, the clay is worked by stripping at the outcrop back in the hill until the overburden becomes too heavy to remove with profit, when a drift or mine is run in from the face and the process continued under ground. The mining or quarrying is in nearly all cases done by blasting, in which the blasting auger, similar to that used in coal mining, is used. After blasting, the clay is loaded on tram cars and run directly to the works when the latter are close by the pit or mine; or, where distant, it is loaded into wagons or flat cars and hauled thereto.

Pl. XXI.



Residences made of rock-faced vitrified brick; the upper one that of I. G. Poston, Crawfordsville, Ind.

PREPARATION OF CLAYS.—But few clays are found in their natural state in such a condition that they can be taken directly from the deposit where they lie to the machine which shapes them into the unburned product. Almost all have to undergo some process of preparation in order that they may be reduced to a fine grained, homogeneous and plastic mass. While this preparation is more necessary and thorough in the making of the finer grades of clay wares, the manufacturers of paving brick are beginning to realize that on account of the more rigid inspection and close competition of their products, more care must in the future be taken in the preliminary mixing and preparation of their clays. Especially is this true of such clays as contain foreign impurities, such as small nodules of iron carbonate or pebbles of lime. If not present in too great quantity, these, when ground fine and intimately mixed with the mass of clay, do little harm. But if allowed to pass into the body of the brick, or other ware, in coarse granules, a large percentage of the finished product will be rendered wholly worthless. Where two or more clays are to be mixed together, the mixing must be thoroughly and uniformly accomplished, else the toughness and general structure of the brick will be greatly impaired.

The quality of almost all clays is greatly improved by weathering. While the amount of material used in a paving brick factory is so large that such a procedure becomes in part impracticable, yet if the conditions are such that large quantities of the clay can be gotten out in summer and allowed to remain exposed to the winter's rains and frosts, a tougher and better grade product will invariably result therefrom.

Although both shales and under-clays are sedimentary deposits, their natural plasticity has been largely destroyed by the changes which they have undergone subsequent to their deposition. This plasticity can be restored only by grinding and kneading with water. Where large amounts of the clay have to be used, this grinding is almost universally accomplished by means of a machine called a "dry pan." If the shale or clay is very hard, or is gotten out in large pieces, it is often first run through a disintegrator or crusher, such as the Joplin ore crusher, and from that passes into the dry pan. Experience has proven that for the making of paving brick a dry pan nine feet in diameter,

supported by an iron frame, and having the rim of the inner wheels or mullers from 10 to 12 inches wide, is the most suitable. With such a machine dry shale sufficient in quantity to make 30,000 to 35,000 ordinary sized paving brick can be readily ground in ten hours. Where the shale or clay is wet or very plastic, or where the same or a greater number of the larger paving block are desired, two dry pans have to be used. These are set side by side, and in the larger and more modern factories have the clay delivered to them on an inclined chute. Such an arrangement is a great labor saver, as both pans can be tended by one man instead of requiring a half dozen or more, as in the older factories.

A part of the bottom of the dry pan is made of iron plates, with openings varying from one-sixteenth to one-eighth of an inch in diameter. Through these the ground clay passes and is caught and elevated, generally by a bucket elevator, and then dumped onto screens. Through these screens the particles of clay, of sufficient fineness to enter the substance of the brick, pass to the wet pan or pug mill, while the tailings, or those too coarse for such a purpose are returned to the dry pan and re-ground. The kinds of screens used are many. Those known as fixed inclined, or gravity screens are best suited for use in tall buildings, as they are simple and cheap, and require no power to operate them. For low buildings some style of vibrating screen is the simplest, cheapest and most saving of power. Rotary screens, while capable of performing much work, are wasteful of power and are very liable to get out of order.

The most important preparatory process through which clays are put is the tempering, or mixing with water, in order to develop sufficient plasticity for making them into the product desired. In the manufacture of paving brick the clay is most commonly tempered in pug mills. These are much cheaper and less cumbersome than wet pans, but the latter give far better results, as by them the particles of clay are not only *mixed* with those of the water, but are *ground* into intimate contact with them. The wet pan is a heavy revolving iron pan with two very heavy iron rollers revolving inside. There are numerous sizes and styles, but all operate on the same principle. Some are emptied automatically and some by hand. The wet pan is more

suitable for mixing clays of different kinds, as a pug mill merely stirs their particles together without bringing them into close contact. However, these advantages are commonly overlooked and the cheapness and simplicity of the horizontal pug mill, coupled with the fact that it requires less attention, leads to its more common use. These pug mills are of numerous sizes and varieties but all work on the same principle.

If possible, some sort of a storage bin should intervene between the screen and the pug mill, and above the latter. This will secure a more regular flow of clay into the mill, and thereby render its work more uniform and efficient. Difficulty will very likely be experienced, however, in getting the ground clay to run freely from the storage bin, as it will have a strong tendency to bank up and clog the openings. The use of warm water in tempering, especially in winter, will be found to add much to the ease with which the clays may be worked, and will, at the same time, improve the quality of the finished product.

The processes of preparation thus briefly described are not limited to the paving brick industry, but are practically the same in all factories using indurated clays, whether for vitrified, refractory or other products.

MAKING OF BRICK.—Paving brick are now almost universally made by what is known as the "stiff-mud" process. In this process the ground clay is moistened just enough to render it plastic without becoming soft and pasty. The brick formed from it, on leaving the machine, are firm enough to be handled and piled several courses high without breaking or losing their shape. Stiff mud brick are made in all Indiana factories on what are known as auger machines. These are of many different patterns but all work on the same principle. Each machine consists of a horizontal closed tube or cylinder with a cone-shaped front end. The clay is admitted on top of the rear end of this tube, and is pushed forward much in the same manner as the meat in a sausage mill, by a set of blades or knives which are arranged spirally about an inner revolving, horizontal shaft. These blades both cut and pug the clay, and carry it forward to the auger, or screw, working in the cone-shaped portion of the machine. This auger is a solid iron screw with a single or double thread. Gathering up the clay it forces it from the larger to the smaller

end of the cone, thereby compressing it greatly and causing it to issue through the die at the front opening in a steady and continuous stream or bar. This may be 4x9 inches in size, and is then cut off in sections three and a half inches thick into "side-cut" block; or it may be $3\frac{1}{2}$ x4 inches in dimensions, when it is cut into sections nine inches long, producing "end-cut" block. The cutting of the bar of clay into sections of the proper dimensions is effected by wires attached to a frame, which is operated either by hand or by automatic machinery. The same machine can be readily changed from a side-cutting to an end-cutting by changing the size of the die on the end through which the clay is forced. Not only common sized brick for paving or building purposes can be made on one of these auger machines, but also hollow brick, fireproofing, tiling and many other forms of clay wares. In fact, there is scarcely any limit to the variety of products that can be made by simply changing the die through which the clay is forced.

Another form of machine, but less used in Indiana for making stiff mud products, is the plunger machine. In it the tempered clay is pushed into a closed space or press chamber and then forced out through the die by means of a piston or plunger, which is operated intermittently by steam pressure. This style of machine is much less used than the auger for several reasons, chief among which are: (a) Numerous defects in the brick, caused by bubbles of air which have passed with the clay into the press chamber and, finding no means of escape, have been forced into the body of the brick and caused therein voids or cavities which weaken its strength; (b) the intermittent nature of the flow of clay which prevents the use of automatic machinery in handling the output; (c) the necessary dividing of the steam power of the engine in order to furnish the pressure necessary to operate the piston; (d) the cost of the plunger machine, which is usually considerably more than that of the auger.

Stiff mud brick, however made, are apt to have certain defects, some of which it is hard to avoid. The most common of these is a laminated condition of the inner portion of the brick. This is, for the most part, due to the outer portions of the bar of clay being retarded by friction against the sides of the die as it is forced through it by either plunger or auger, while the

inner portion, exempt from such friction, moves more rapidly onward. These laminations are less frequent in large bars of clay than in small ones, as a smaller proportion of the clay is in contact with the die. Hence the side-cut machines produce fewer of them than the end-cut. For this reason more of the former are used, especially in the making of paving brick from soft, gritless shales or "soapstones," which have a stronger tendency toward lamination than the harder, more nonplastic clays. All things considered, experience has proven that the side-cut auger machines are the best adapted to the making of paving brick from such raw materials as occur in Indiana. Five of the six factories now in operation are using such machines. Two of these began with end-cut machines but found them unsuitable for working the shales. The latest improved side-cut auger machines, of which there are several patterns on the market, when supplied with the latest improved cutting table and automatic off-bearing belts, are capable of making 40,000 brick in ten hours' time.

In most factories the brick are taken from the cutting table and passed through a repress machine before they are taken to the dryer. The value of this process is as yet a mooted question among paving brick makers. The prevailing opinion at present is that repressing improves the brick in smoothness and general appearance but not in structure. The corners are rounded off and the rough sides, caused by the passage of the cutting wires through the clay, are obliterated. Two represses, each requiring the services of two men, are necessary to take care of the output of a single, side-cut, auger brick machine.

DRYING THE BRICK.—After the brick have been given their shape on the cutting table or the repress, the next process in their manufacture is the driving off of the water which has been added to the clay to secure plasticity. The average daily output of a single modern side-cut machine contains almost 20 tons of this water. How to remove it quickly and cheaply by evaporation has been a question which has sorely puzzled paving brick makers in the past. Many methods have been devised, but the one now most used, and which will most probably be connected with such paving brick plants as will be erected in the future, is known as the progressive or tunnel system. By this system

small iron cars, single or double decked, each holding from 350 to 500 of the undried block or brick, are pushed in at one end of a long, low tunnel or dry house, and by slow progression moved forward to the other end. This tunnel has close fitting doors at each end, and two to four sets of double tracks. Oftentimes four to eight tunnels are combined in one drier or dry house. In the most modern dryers "waste heat" from the kilns which have just been burned is used. Formerly the kiln was opened as soon as the burning was completed, and this heat allowed to escape. Now, by the waste heat process of drying, it is forced through underground tunnels by a large revolving fan to the dryhouse and much saving of fuel thereby accomplished. The kilns are attached, as desired, to the underground tunnels by iron goose necks inserted in the door of the cooling kiln and in the manhole opposite the kiln door. Much saving of time is effected by the waste heat process, as the freshly burned kilns of ware can be cooled in four days, whereas, under the old method, it often required seven.

The waste heat process is now being used at a number of the larger clay working factories in the State, and will doubtless be adopted at others. At some of the older factories steam or direct heat are used. In the former many thousand feet of radiating and coiled steam pipes are laid beneath each drier. These are most abundant at the end of the tunnel nearest the kiln for which the dried brick or other wares are intended.

In drying the brick, the loaded car is run in at one end, and when the next car is put in, the one in front is pushed forward a car length, and is thus moved slowly to the other end of the tunnel, the rate being so regulated that the bricks are dry enough to stack in the burning kiln when they reach the far end of the drying tunnel. In general the temperature in the tunnel is so controlled as to be lowest at the near end where the cars first enter and highest at the end from which they emerge. The new carload of brick does not dry to any extent, but it begins to warm through, till each individual brick is as hot as the surrounding atmosphere. As the cars are shoved down the tunnel, each advancing one finds itself in an atmosphere a little warmer. The water now begins to dry on the surface of the bricks, and as they have been previously brought to a warm steamy condition,

the surface evaporation is constantly replaced by moisture from the inside. Hence there is no tendency for the outside of the brick to contract faster than the inside and, therefore, no tendency to cracking or breaking. As the bricks proceed onward they yield up successive portions of their moisture, and finally emerge from the hot end of the drier ready for the kiln. The daily output of an average factory can be dried ready for setting in the kilns in from 24 to 30 hours by the latest styles of progressive driers.

BURNING THE BRICK.—All other processes of clay manufacturing are subordinate in importance to that of the burning. Especially is this true of the manufacture of paving brick where, upon the proper management of the burning, more than upon the quality of the clay or its preparation, depends the degree of vitrification and toughness which the finished product will possess. For the most part, the burning of vitrified products is carried on in down-draft kilns. These are of several patterns, the most common of which is the round down-draft, from 26 to 30 feet in diameter and holding 28 to 35 thousand standard block, or 40 to 45 thousand ordinary sized brick. On account of the importance of this process, the following full and valuable account of the proper method of burning ordinary sized paving brick is taken from the *Clay Worker*. It was written by that noted authority on all subjects pertaining to clays, Prof. Edward Orton, Jr., of Columbus, Ohio:

The kiln may be supposed to be twenty-five feet in diameter, with ten fire holes of the inclined grate style, and the contents of the kiln are set twenty-five courses high. The fires are lighted at once, when the setters have finished their work and erected a single wicket in each door. The fires at first are very small, not over one-half bushel in cubic contents, and are at the bottom of the grate bars and in the foot of the bag. They are maintained at about this stage for the first twelve hours, when they are doubled in size. The temperature of the waste gases passing off in the stack at the end of twelve hours will be milk warm or a little more. During the first three days the draft of the kiln is apt to be too feeble rather than too strong, so under usual conditions the stack has full chance, unobstructed by damper of any kind. The air supply entering the kiln during the first day is very large, as it has nearly the whole area of each fire hole. This space is gradually filled up as the size of the fires increase, so that the temperature of the gases passing into the kiln insensibly increases, hour by hour, as the air passages are diminished and the fires increased. During the first twenty-four hours the wickets, peep-

holes and all openings except the fire holes should be finished up and daubed with mud and washed with clay-slip till air tight.

During the second twenty-four hours the fires are again doubled, the increase being carefully distributed throughout the day. This will about half fill the fire holes, leaving the upper half of the openings free for air. The waste gases in the draft stack will feel much warmer at the end of the second day—probably from 140 degrees to 160 degrees, and they are so laden with water that they appear as clouds of steam if the outside air is cool. During the third day the fires are slightly increased, but not so as to more than two-thirds fill the fire holes. The waste gases rapidly increase in heat during the day, usually getting too hot for the bare hand, and the visible steam becomes less and less, generally disappearing before the end of twenty-four hours.

The kiln has now passed through what is called in the trade the "water-smoking" period. The water discharged is largely that which is free and merely left in the bricks from the dryers, though possibly some combined water has been expelled during the third day. The intention of the burner during this period is to subject the bricks to a liberal flow of air and gases, beginning at a low heat, and by the end of the third day attaining a temperature of 300 or 400 degrees. If this is done the last traces of free water will have been drawn out, and the kiln will be ready for raising "fires."

The fire holes are now filled up so that the air supply is nearly cut off, and what air does draw in over the top of the fire is hardly more than sufficient to consume the inflammable gases from in rear of the fires. Under this condition the fire holes soon become red, and soon after the bags and fire walls are seen to be red as well, and during the second half of the fourth day the bricks will become a dull red, easily seen at night and with difficulty by day. It is at this stage that the combined water is expelled, and the utmost caution and regularity are needed. The heat must be maintained and slightly increased, hour by hour, constantly aiming to cause the redness to travel downwards, course by course, without materially increasing the temperature of the top.

The draft, if too strong, must be cut down, and the heat regulated by the size of the air inlets over the top of the fires. In cold weather steam will be seen for the second time during this day, but in warm weather the superheated vapor is absorbed into the atmosphere without condensation.

The kiln should be gauged—that is, the distance from the top of the bricks to the top of the kiln should be carefully measured—during the fourth day, as soon as the bricks are hot enough to distinguish, or before. This figure should be noted down for future reference. During the fifth day the air supply will be nearly cut off, and the fire holes will be at their full heat. The temperature at the beginning of the day should be distinctly red on top and a barely visible red in the middle peep-hole on the twelfth course from the bottom. During the twenty-four hours the heat should be increased to a clear, bright cherry red on top, decreasing to a distinctly visible red on the bottom of the kiln, and on the draft stack. When this color is seen in the stack it is a sign that the necessary heat to expel the combined water from the clay has been

attained from top to bottom, and that the bricks are now ready to take the finishing temperatures as fast as they can absorb them. The constant danger will be, during the fifth and subsequent days, that the top courses will become overheated for a few moments. If the burner is not constantly on the qui vive, after every firing, especially, the heat will become too great and the quality of the top courses will be damaged or ruined. If the work is skillfully done the top courses will be still only a good, hard building brick at the close of the fifth day, while the bottom has arrived at the softest salmon stage.

On the sixth day the finishing process or "high fire" begins. So far the rise in temperature has been comparatively regular and gradual. But after the gases have been expelled from the clay the danger of sudden changes in the heat is only that the highest limit may be exceeded; variations inside of that limit do no harm. The fires are managed much as before, the air supply being greater or less according to the heat needed for the moment. The top of the kiln becomes heated up to its practical limit of safety a few hours after the finishing process begins, and if the heat is still maintained without cessation the bricks will soon become spongy. If the heat be kept on for a few hours, until the top bricks begin to show signs of distress, and then allowed to cool off somewhat, together with an increase of draft, it is found that the top portions of the kiln will give out heat again, and, while cooling down themselves, they assist in bringing up the heat of the courses below them.

By working the kiln as described and carrying wave after wave of heat from the top downwards the bottom of the kiln ought to become strongly red by the end of the sixth day, the top being as hard as is desired before this time. The gauge at this stage should show about five or six inches settle from the first figure, with a setting 25 courses high.

The same method of firing during each succeeding 12 hours ought to show a further settle of two inches. By the end of the seventh day the settle will probably be 9 or 10 inches, and the trials taken from the top, middle and bottom will show the vitrification to be complete on top, fair in the middle and too soft on the bottom. Twelve hours more ought to bring the heat down to the bottom so that the settle shows 11 or 12 inches and the trial a hard building brick or poorly vitrified paver. The burn is ready to conclude at any time the burner sees fit, and he must now weigh in his mind the benefit and danger of each fire before putting it on. The conclusion of a burn under such conditions as have been described should not be later than the middle or end of the eighth day.

In cooling off the practice varies. Experience has shown that the danger point in cooling vitrified clay ware is at a dark red or black heat. When the ware is very hot it can not be damaged by free admission of air, providing that it all enters through the fire holes and red-hot flues. The proper plan is to allow the kiln to cool down under full draft until it begins to look dark, then shut the dampers and cool as slowly as the kiln capacity will allow. Three to six days are allowed to round kilns.

The slower the cooling the greater toughness is found in the product. The top course and the bricks immediately next the bags are always likely to be brittle in any case, as they are heated up and cooled down many times in the burn in accumulating the waves of heat by which the bottom courses are reached.

COST OF A PAVING BRICK PLANT.—The cost of a paving brick factory fitted up with modern machinery varies much, according to location, size, etc. In order to have the judgment of practical paving brick manufacturers on the question of cost of such a factory, Mr. I. G. Poston, superintendent of the Poston Paving Brick Co., of Crawfordsville, and Mr. W. P. Blair, superintendent of the Terre Haute Brick and Pipe Co., at Terre Haute, were asked to furnish estimates of a modernly equipped factory, having a capacity of 40,000 paving block per day. They kindly complied with the request, and their estimates, given verbatim, herewith follow:

BY I. G. POSTON.

Crawfordsville, Ind., February 20, 1905.

Estimate of cost of a modern paving brick plant with a daily capacity of 40,000 8-pound paving blocks per day. (Size of block, 3x4x8½ inches.)

<i>Classification.</i>	<i>Requirements.</i>	<i>Cost.</i>
Kilns—Sixteen 30-ft. (inside) round down-draft, with stacks (arranged in groups of four), with one stack (partitioned) to each group.....		\$24,000
Buildings—Machinery building 40x100 ft. (divided into (a) boiler room, (b) engine room and (c) machinery room), stable, machine shop and office.....		6,000
Dryer—Ten-tunnel waste-heat dryer (brick and concrete construction), with a 12-foot waste-heat fan and underground flues to kiln, complete with steel car equipment.....		7,000
Machinery—Two 150 h. p. boilers, one 250 h. p. Corliss engine, two stokers, two 9-ft. dry fans, one 12-ft. pug mill, one heavy auger brick machine, one cutting-table, two double represses, elevators, shaftings, beltings, etc., complete....		15,000
Incidental—Land, tools, office furniture, etc.....		3,000
Total		\$55,000

BY W. P. BLAIR.

Terre Haute, Ind., February 10, 1905.

Estimate for modern paving brick plant, having 40,000 daily capacity.

A.—Sixteen down-draft kilns, 30 ft. diameter, at \$2,500.....	\$40,000
B.—Sixteen-track tunnel dryers, with tunnels for waste-heat, including equipment of cars, fans, tracks and engines, etc.....	20,000
C.—Machinery, power and factory equipment.....	35,000
D.—Buildings, etc	10,000

In the foregoing estimate no account of cost for water, railway facilities, shipping yards, sewerage, delivery of clay into plant, etc., is provided for, which must vary much according to location and conditions, and do cost from \$10,000 to \$30,000 30,000

Total\$135,000

It will be seen that a wide divergence exists between the estimates of the two gentlemen. From figures gained from other sources and from close personal observation of a number of factories, it is believed that the average cost will be about \$1,500 for each 1,000 daily capacity of output. This does not include the cost of railway switches, nor the capital necessary to carry on the business before the returns begin to come in.

COST OF MAKING PAVING BRICK.—This also varies much according to location and size of plant, price of labor, cost of fuel, etc. Where a factory is fitted up with modern machinery, has an output of 35,000 or more daily, and is situated by the side of the clay, fuel and water, so that these necessities can be obtained at a minimum price, the actual cost of making repressed paving brick and putting them on board the cars, is in the immediate neighborhood of \$6.00 per thousand; of block, \$6.50 per thousand. To this must be added the interest on capital invested, insurance, taxes, office expenses, salaries of salesmen and all other general expenses, which will bring the cost up to near \$6.50 per thousand for the brick and \$7.00 for the block. The prices at which they now sell in Indiana are said by the makers to average about \$10.00 for the brick and \$11.00 for the block on board the cars at the factory. This includes "seconds" and "culls."

THE TESTING OF PAVING BRICK.—The question of the proper tests to which samples of the brick destined for paving streets shall be subjected is a most important one. Each city engineer has, usually, his own opinions on this matter, and makes his tests according to his own best judgment.

As already stated, the two essential qualities of a good paving brick are vitrification and toughness. Hence, the most important tests which can be made are those which will go to prove the presence of these qualities in proper degree. These are the absorption test and the abrasion or rattling test. The following

method of making the absorption test is given as one which has been commended by experts:

One whole and three half bricks of average hardness, which are free from kiln sand and which have not been subjected to the abrasion test, should be taken. These should be dried carefully over a register or in a radiator for 24 hours, at a temperature between 200 and 300 degrees. Each specimen should then be weighed accurately on scales which are graduated to at least one-fourth of an ounce, and a record kept of their separate and combined weights. They should then be soaked in clear water for 24 hours, after which they should be wiped dry with a cloth and weighed again. The increase in weight denotes the amount of water absorbed. The sum of this should be reduced to a percentage of the dry weight, and this will be the per cent. of absorption. The maximum amount of this which is allowable in a paving brick is, as yet, an unsettled question. Some city engineers make two per cent. the limit. More fix the amount at one and a half per cent. By far the greater number of paving brick placed upon the market show a gain of less than one per cent., so that two per cent. is probably not far from the limit which it is best to allow. No brick should be condemned or endorsed on the absorption test alone, as such a test is an index only of the quality of vitrification, and gives no proof of the presence of the other qualities which the brick must possess.

For the abrasion test, which is made to indicate the toughness of the pavers, and is therefore by far the most important, the following specifications for machine and test have been adopted by the National Brick Manufacturers' Association, and may be recognized as the standard:

NATIONAL BRICK MANUFACTURERS' ASSOCIATION SPECIFICATIONS
FOR STANDARD METHOD OF CONDUCTING THE RATTLER TEST
FOR PAVING BRICK.

I. Dimensions of the Machine.—The standard machine shall be 28 inches in diameter and 20 inches in length, measured inside the rattling chamber.

Other machines may be used, varying in diameter between 26 and 30 inches, and in length from 18 to 24 inches, but if this

is done, a record of it must be attached to the official report. Long rattlers must be cut up into sections of suitable length by the insertion of an iron diaphragm at the proper point.

II. Construction of the Machine.—The barrel may be driven by trunnions at one or both ends, or by rollers underneath, but in no case shall a shaft pass through the rattler chamber. The cross-section of the barrel shall be a regular polygon, having fourteen sides. The heads shall be composed of gray cast-iron, not chilled nor case-hardened. The staves shall preferably be composed of steel plates, as cast-iron peens and ultimately breaks under the wearing action on the inside. There shall be a space of one-fourth of an inch between the staves for the escape of the dust and small pieces of waste.

Other machines may be used having from twelve to sixteen staves, with openings from one-eighth to three-eighths of an inch between staves, but if this is done a record of it must be attached to the official report of the test.

III. Composition of the Charge.—All tests must be executed on charges containing but one make of paving material at a time. The charge shall be composed of the brick to be tested and iron abrasive material. The brick charge shall consist of that number of whole bricks or blocks whose combined volume most nearly amounts to 1,000 cubic inches, or eight per cent. of the cubic contents of the rattling chamber. (Nine, 10 or 11 are the number required for the ordinary sizes on the market.) The abrasive charge shall consist of 300 pounds of shot made of ordinary machinery cast-iron. This shot shall be of two sizes, as described below, and the shot charge shall be composed of one-fourth (75 pounds) of the larger size and three-fourths (225 pounds) of the smaller size.

IV. Size of the Shot.—The larger size shall weigh about seven and one-half pounds and be about two and one-half inches square and four and one-half inches long, with slightly rounded edges. The smaller size shall be one and one-half-inch cubes, weighing about seven-eighths of a pound each, with square corners and edges. The individual shot shall be replaced by new ones when they have lost one-tenth of their original weight.

V. Revolutions of the Charge.—The number of revolutions of the Standard test shall be 1,800, and the speed of rotation

shall not fall below 28 nor exceed 30 per minute. The belt power shall be sufficient to rotate the rattler at the same speed whether charged or empty.

VI. Condition of the Charge.—The bricks composing a charge shall be thoroughly dried before making the test.

VII. The Calculation of the Results.—The loss shall be calculated in percentages of the weight of the dry brick composing the charge, and no results shall be considered as official unless it is the average of two distinct and complete tests, made on separate charges of brick.

The length of time to which the brick shall be subjected to the test and the maximum loss which they may sustain were not included in the above specifications. The Indiana manufacturers of vitrified paving brick and block have, however, recommended the following as a reasonable test covering the two omitted points:

“The brick or block shall be submitted to a test of one hour in the standard rattler, and if the loss by abrasion during such test exceeds 20 per cent. of the original weight of the brick tested, then such brick or block shall be rejected.”

The abrasion and absorption tests of paving brick or block are the principal ones in use as, if properly made, they prove the presence or absence of the proper degree of toughness and vitrification. Other tests which probably should be made are those showing the hardness and the cross-breaking or transverse strength. The former is easily determined by the use of the scale of hardness or scratching test, as the ability to scratch or to be scratched determines the relative hardness of any two substances. This scale is explained in all works on elementary physics, and is the one commonly in vogue with mineralogists. Its numbers run from one to ten, and certain well known minerals are taken as types of each degree, talc or soapstone being No. 1; calcite No. 3, etc. Nos. 6 and 7 represented respectively by feldspar, a common constituent of granite rocks, and quartz, a very common mineral, are the two degrees of the scale which should be used comparatively in testing paving brick. No brick should be used for street purposes whose hardness is not six or above, while none showing a hardness above seven are made. In making the test the inspector should be provided with pieces of

feldspar and quartz 2x4 inches, or larger in size, and also with an ordinary three-cornered file. The file should be drawn with considerable pressure over the narrow face or edge of the brick, and with the same amount of pressure over both the feldspar and the quartz, and observation made as to whether the depth of the cut in the brick is greater, less or equal to that made in the minerals. If the scratch in the brick is less than that in the feldspar and deeper than that in the quartz, the hardness of the brick is between six and 7, or the one desired; but if the scratch in the brick is plainer and deeper than that in the feldspar the brick is too soft and should be rejected. If doubt occurs as to the pressure exerted by the file being the same in each instance, a piece of the brick can be used on the smooth surfaces of the pieces of the minerals, and *vice versa*. The harder bodies will scratch the softer.

In making the transverse or cross-breaking test, the brick should be placed edgewise on rounded knife edges, set six inches apart, and the load applied in the center by a rounded knife edge until the brick is broken. The transverse or tensile strength is then determined by the following formula:

$$f = \frac{3 W l}{2 b h^2}$$

in which

f = tensile strength in pounds per square inch.

W = breaking load in pounds.

l = length between the bearings.

b = breadth of brick.

h = height of brick.

The crushing test for brick was at one time largely used, but of late years has been considered of little value. "The crushing strength of a cube cut from a good paving brick is, say, 8,000 to 10,000 pounds per square inch, and if the pressure is applied on only a portion of the upper surface the strength is about twice as much. The surface of contact between a wheel having a one and one-half-inch tire, loaded with half a ton, is roughly about one square inch, which gives a pressure on the brick of only 1,000 pounds per square inch. Therefore there is no danger of the brick being crushed."* If made, the brick to be tested

* Baker, I. O., *Brick Pavements*, p. 8.

should be placed edgewise, and the edges should be previously ground smooth, else the real strength will not be obtained.

If the four tests of absorption, abrasion, hardness and transverse strength have been made, it becomes necessary to average them, as in most cases one sample will show the highest per cent. in one particular, and a second in another particular. The question then arises, what relative value or weight should be given to each test? Regarding this point opinions widely differ. Prof. Edward Orton, in a recent letter, states that the Committee of the National Brick Manufacturers' Association has "discussed the questions of absorption, hardness, cross-breaking, crushing, etc., and the conclusions reached were that none of these tests were of any material value in determining the relative merits of the different brands of paving brick. And my experience in the last three or four years during which I have tested many hundreds of samples is very much in accordance with these views. I do not see what knowledge we gain of paving brick, which is of value to the case, in making a cross-breaking and crushing test, or even an absorption test. If I thought we gained any better knowledge of the wearing power by making this test, I should be only too glad to make it, of course. But I can not see where the value to the user or the brick manufacturer comes in. If I were writing a report on this subject at present I should take this ground, and recommend that for paving brick the test should be confined to the rattler method."

Many city engineers, however, require that the sample brick be put to other tests, and as the qualities of toughness and vitrification are most desired, it is obvious that the tests of rattling and absorption should be rated higher than the other two in making out the average. Probably the best relative value which can be given each of the four in making out the final average is as follows:

Rattling	60 per cent.
Absorption	20 per cent.
Hardness	10 per cent.
Transverse strength	10 per cent.

The engineer in prescribing his specifications for bids should make known fully the manner in which each test shall be made, and the relative weight which shall be given each in computing the final average.

THE FORMATION OF BRICK PAVEMENT.—While the making of brick streets is an industry entirely distinct from that of the manufacture of paving brick, the future of the latter industry depends wholly upon the successful wear of such streets and the satisfaction which they give to the general public.

Many brick pavements which have been put down in the past have proven costly investments, but a much larger number have proven entirely satisfactory both in comparative cost and wear. The failure of those unsatisfactory has been due to many causes. One of the most common of these has been the use of poor foundations. It has been long proven by experience that no matter how superior the wearing surface of the street may be, unless such surface is supported upon a firm and enduring foundation its lease of life will be short. Another common cause of failure has been the use of a poor grouting or filler, or the use of none at all.

Possibly the best examples of vitrified pavements in Indiana are to be found in the brick streets of Terre Haute. A number of these pavements have been in use from 10 to 15 years and show no perceptible wear, though subjected daily to the heaviest of traffic. In many cases entire blocks are wearing smooth and becoming more of an ideal street each year. This condition has been brought about by the skillful, minute and careful construction in detail of specifications urged by George R. Grimes, city civil engineer, of Terre Haute, and as recommended by the National Association of Brick Manufacturers of the United States.

Mr. W. P. Blair, of Terre Haute, kindly furnished me a copy of the specifications used in that city, prefacing them with the following remarks:

On the Importance of the Proper Construction of Brick Pavements.

"Indiana utilizes, with loyal appreciation, the products of her own resources to a commendable degree, yet this spirit and loyalty may be increased many fold, to the decided advantage, welfare and comfort of our citizenship. In no other direction can this be more so than in the liberal and proper utilization of her shale product, cement stone and gravel in the proper and permanent construction of her streets and highways. Few States of

the Union are favored with such an extended area of distribution of stone and gravel as is Indiana, thus bringing the cost of either to a minimum. As will be noted throughout this report on 'Clays and Clay Industries,' Western Indiana affords sites sufficient for all capital desiring to enter the field for the manufacture of shale products. Even now six Indiana companies—grown to be large institutions—are engaged in the specialty of manufacturing vitrified brick for street and roadway purposes, and afford such competition that streets in Indiana may be built of the best character at a price ranging from \$1.50 to \$1.75 per square yard. These companies and their locations are as follows:

"The Terre Haute Brick and Pipe Company, Terre Haute.

"The Indiana Paving Brick and Block Company, Brazil.

"The Wabash Clay Company, Veedersburg.

"The Clinton Paving Brick Company, Clinton.

"The Poston Paving Brick Company, Crawfordsville.

"The Evansville Pressed Brick Company, Evansville.

"Cement concrete sidewalks and, also, stone and gravel roadways have reached a high state of perfection. It seems to be almost universally known how best to build them, but not entirely so. In the case of the brick street or roadway the difference is so great by comparison between a street built in the best-known way and one that is constructed without taking advantage of the details so essential to the best that we think it is not out of place to incorporate here with minuteness the directions and suggestions that, carefully and skillfully followed, have produced really wonderful results. In the city of Terre Haute there are some streets now from 10 to 15 years old showing no perceptible wear, save that sufficient only to reduce the slightly uneven condition as when new to the perfectly smooth plane shown in their present condition. These furnish, without a doubt, the most convincing examples of perfectly constructed brick streets known.

"The fact that the above-named Indiana manufacturers of vitrified shale brick, out of their own anxiety to bring more and more into favor their product, fully endorse the following method of construction adds greatly to its value. The specifications that follow were not written in a hurry. We did not write them in an hour; we did not write them in a week; we did not write them in a year. It took 15 years of hard study to determine just what

was best, and when these specifications were completed, two or three years ago, we knew from experience that they would stand the test of time.

"In view of the high degree of perfection that is made possible in the brick streets by adhering closely to these specifications, as well as the extraordinary sanitation afforded by them, and the fact that they can be made wholly out of material the product of our own State, it would seem that the mileage of such brick pavements should rapidly grow."

*Specifications for the Construction of Brick Pavements in the
City of Terre Haute, Indiana.*

Substructure or Grading.—Earth in excavation to be removed with plow and scraper, or other device, to within two (2) inches of subgrade, then brought to true grade with the roller, the weight of which should not be less than five (5) nor more than eight (8) tons. If the earth is too hard to receive compression through the weight of the roller, then loosen the remaining two (2) inches with a pick and cart away. Earth in embankment must be applied in layers of eight (8) inches in thickness and each layer thoroughly rolled, and in both excavation and embankment the subgrade must have a uniform density. If the ground is a spouty clay, tile drainage should be provided to carry off this accumulation of wet.

Curbing.—If cement is used, it should be completed; if stone, all should be hauled and distributed and set before the grading is finished, and may then be used as a guide to finish the subgrade. It should range in thickness from four (4) to six (6) inches, twenty (20) to twenty-four (24) inches wide, the business and street traffic governing the same, and lengths not shorter than five (5) feet, except at closures. Neatly dressed on top with a square or rounded edge and four (4) inches down on the inside. The outer surface to be tool-dressed to the depth of the face exposed and to the depth of the thickness of the brick and sand cushion. The intersection of street corners and alleys should be circular, with radius of four (4) and three (3) feet, respectively.

Marginal Curb.—Should always be of a hard and durable character of stone and from fourteen (14) to (18) inches deep, dressed

on top and five (5) inches down on the face next to the brick. Set to accurately fit the curvature of the cross-section of the street on six (6) inches of concrete and backed up with the same within six (6) inches of the top.

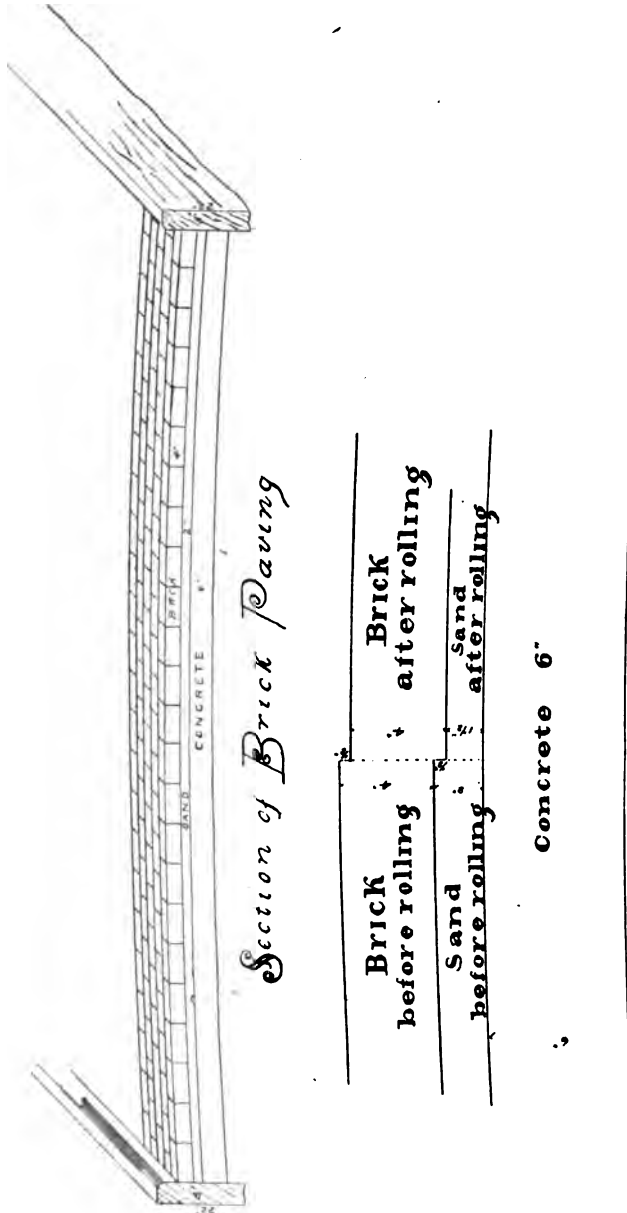


Fig. 12. Construction of Brick Pavements Illustrated.

Concrete Foundation—Crushed Stone.—Should be of approved quality of hard rock, with no fragment larger than will pass through a two (2) inch ring, and no smaller than will pass through a one (1) inch ring in their longest dimensions, free from all refuse and foreign matter.

Sand.—Must be clean, sharp and dry and thoroughly mixed in its dry state until the whole mass shows an even shade, with an approved brand of either hydraulic or Portland cement. If hydraulic, the proportion of mixture should be one part of cement and two parts of sand; if Portland cement, one part of cement and three parts of sand. To the above mixture should be added sufficient clean water to mix to a plastic mass, fluid enough to rapidly subside when attempting to heap to a cone shape. To this mixture add four (4) and five (5) parts, respectively, of damp crushed stone or clean screened gravel, and turn the whole mass over not less than three (3) times, or until every fragment is thoroughly coated with the cement mixture. For the reception of this mixture the grade should be set off in five (5) foot squares, with a stake at each corner. Tops of each should be at the surface of concrete, which must be tamped until free mortar appears at the surface. Occasional sprinkling in extreme hot, dry weather is beneficial. After thirty-six hours the cushion sand may be spread.

Sand Cushion.—Sand should be clean and free from foreign or loamy matter. It need not necessarily be sharp. It should be two (2) inches thick before the compression of the brick by rolling. The sand should be spread by the aid of a template, the whole or one-half the width of the street, made to conform with the true curvature of the street cross-section.

Brick.—The brick should all be hauled and neatly piled inside of the curb line before the grading is finished, or, if allowed by the engineer, delivered on the street in wagons and carried from the pile or wagon on pallets or with clamps, and not wheeled with barrows. They should be first-class and thoroughly vitrified, showing at least one fairly straight face, if with rounded edges, with no greater radius than 3-16 of an inch. They should not be less than $2\frac{1}{2} \times 4 \times 8$ or more than $3\frac{1}{2} \times 4 \times 9$ inches, free from cracks, with but slight lamination, and at least one edge with but slight kiln marks allowed.

Such brick or blocks shall be submitted to a test of one hour in

the National Brick Manufacturers' Association standard rattler and under the conditions prescribed by that association, and if the loss by abrasion during such test exceeds 20 per cent. of the original weight of the brick tested, then such brick or blocks shall be rejected.

Brick Laying.—Brick should be laid perpendicular to the curb. Broken brick or block can only be used to break joints in starting courses or in making closures. The brick shall be laid on edge, close together, in straight lines across the roadway between gutters. Gutters shall be constructed as directed by the engineer. After the brick are laid they shall be thoroughly inspected, and all warped, spalled and soft brick removed and replaced by more perfect ones, and those found with the bad face up should be turned down.

Tamping and Rolling.—After the inspection is thus completed the edge of the pavement shall be tamped to grade next to curb to the width of six (6) or eight (8) inches out from the curb with a hand tamper. The entire pavement shall then be rolled with a five (5) ton steam roller until all brick are thoroughly bedded and the whole surface assumes a practical plane, conforming to grading and curvature of roadway.

Expansion Cushion.—An expansion cushion must be provided for, one inch in thickness next to the curb, filled two-thirds of its depth with pitch, the top one-third being filled with sand.

The Filler.—The filler shall be composed of one part each of clean, sharp sand and Portland cement. The sand should be dry. The mixture, not exceeding one-third bushel of the sand, together with a like amount of cement, shall be placed in the box and mixed dry, until the mass assumes an even and unbroken shade. Then water shall be added, forming a liquid mixture of the consistency of thin cream. From the time the water is applied until the last drop is removed and floated into the joints of the brick pavement the same must be kept in constant motion. The mixture shall be removed from the box to the street surface with a scoop shovel, all the while being stirred in the box as the same is being thus emptied. The box for this purpose shall be $3\frac{1}{2}$ to 4 feet long, 27 to 30 inches wide and 14 inches deep, resting on legs of different lengths, so that the mixture will readily float to the lower corner of the box, which should be from 8 to 10 inches above

the pavement. This mixture, from the moment it touches the brick, shall be thoroughly swept into all the joints. Two such boxes shall be provided in case the street is twenty feet or less in width; exceeding twenty feet in width, three boxes should be used.

The work of filling should thus be carried forward in line until an advance of from fifteen to twenty yards has been made, when the same force and appliances shall be turned back and cover the same space again in like manner, except that the mixture for the second coating may be slightly thicker than the first.

To avoid the possibility of too great thickening at any point, there should be a man with a large sprinkling can, the head perforated with small holes, sprinkling gently the surface ahead of the sweepers. This should be done in the application of each course here specified. After the joints are thus filled flush with the top of the bricks, and sufficient time for evaporation has taken place, so that the coating of sand will not absorb any of the mixture, one-half inch of sand shall be spread over the whole surface, and in case the work is subjected to a hot summer sun, an occasional sprinkling, sufficient to dampen the sand, should be followed for two or three days. The grouting thus finished must remain absolutely free from disturbance or traffic of any kind for a period of ten days.

If a high-grade pavement is not secured with the above specifications, the chief causes of failure will be found to be one or more of the following:

The concrete foundation is not smoothly finished.

The true grade is not maintained by the concrete surface.

There must be two inches of sand cushion.

The rolling is attempted with other than a five-ton steam roller.

The rolling is often so slight that the brick stand in the street without support. The rolling must be so thorough that no further compaction can be possible.

More disaster comes to a brick street from the want of properly applying the filler than from any other cause.

A failure to comply with a single direction will easily take away five years of life of a street.

Do not permit a greater amount of filler mixed in one batch than recommended—that alone will spoil the job.

Let the man with the scoop take the mixture from the lower side of the box. Have the man that stirs the mixture stand at lower end of the box. Let the box be immediately adjacent to work. The man with the scoop should move but three or four steps at most from the box. Never allow the mixture to be poured or dumped upon the street from the box. After going to all the trouble to get a street that will last a generation, do not let the cement bond be broken by using it short of ten days, and thus throw away half your money before you spend it.

The Perfect Pavement.—The requirements which shall constitute a perfect pavement have been well summed up as follows:

First. Reasonableness in first cost.

Second. Low in cost of maintenance and easy to repair.

Third. Durability under traffic and reasonable freedom from noise and dust.

Fourth. Free from decay, waterproof and non-absorptive.

Fifth. Of low tractive resistance and furnishing a good foothold for horses.*

Suffice it to say that such a pavement has never as yet been constructed. The nearest approaches to it are those of vitrified brick, made from just such shales as are found in so great abundance in southwestern Indiana.

Mr. Louis H. Gibson has well expressed the facts regarding the best kind of pavement in an article entitled "Points of Perfection in Street Pavements,"† from which several extracts are herewith quoted:

"The perfect pavement, like the perfect man, will only come with the millennium; but, all things considered, the well-laid brick pavement comes the nearest to perfection of any paving material now in use. From the viewpoint of durability and economy, brick pavements certainly are best.

The American asphalt covering has been tried and found wanting. The same is true of wood pavements, for no amount of creosoting or doctoring of any sort can make wooden block durable as a paving material. Its chief point of merit lies in its being comparatively noiseless, but this illy compensates for its unsani-

* Mead, Daniel W., Proc. 9th Ann. Conv. Nat. Brick Manf's. Ass'n. 1895, 34.

† Clay Worker, May, 1904.

tary character as soon as decay sets in. In this respect it is the least desirable of any of our paving materials. The ideal pavement should have a surface which affords a safe foothold for horses. In this respect macadam excels, but it is so lacking in the essential quality of durability and so insufferably dusty during dry weather and muddy in wet weather that it cannot be considered seriously as a permanent paving material. Brick pavements, while not so satisfactory as a speedway for horses as macadam, are less objectionable on this score than either asphalt or wooden block, for horses seldom or never slip on a brick pavement.

In all other respects brick pavement meets all of the conditions of the ideal pavement. It is as enduring as time, does not originate dust, and, being non-absorbent, is a sanitary covering. It is an absolute protection from the earth below, it washes clean, and after a few years develops a gritty surface well suited to the travel of horses. It is easily and cheaply cleaned and requires a minimum of water where sprinkling is desirable, because it is non-absorbent.

Altogether there are five distinct and imperative steps in the construction of a brick pavement. Should there be a failure in any one, the work is a relative failure. They are:

First, the subgrade.

Second, the concrete base.

Third, the sand cushion.

Fourth, the brick and their application.

Fifth, the filler.

There is no one of these points more important than another. Each is imperative.

One authority has said that more disaster comes to a brick street from the want of a proper filler, properly applied, than from any other cause, but if this same authority be followed up the same expressions in regard to each of the points above named will be heard. The fact of the whole business is that there is no difference in importance in the five steps above named. Each is necessary to form a proper integral mass and an ideal pavement.

There has been a constant effort to get rid of the concrete foundation, because it increases the expense of the pavement. Every

one who put down brick pavements in the beginning of their use had a strong underlying impression that the concrete was desirable and necessary, but in each case the individual was struggling against his sense of what he knew to be right.

After it had been discovered that concrete was desirable for foundations, 'any old concrete' was used. It was put on thin on a badly prepared sub-bed, badly mixed, of poor cement, unclean gravel and sand, and laid with little regard to the evenness of the surface. Then the brick were placed almost directly on the concrete. It took some little time for the people and the engineers to find out just what was the matter. Now they know.

If any one will show a pavement constructed without the concrete foundation it will be found to need excuses and explanations. The people who pay for pavements have never favored one because it is cheap. There is always the hope of getting something better. If some one comes along with a pavement that is distinctly better than anything that has ever been presented to the pavement building world before, the people will buy it at a 50 per cent. additional cost. The pavement building world moved directly from cheap gravel and boulders to asphalt and block pavement. They grumbled a little about the cost, but they paid out immense sums in the mere hope of getting something better. The block pavements have been replaced time after time at a great expense, and the asphalt pavements have been patched and resurfaced. But no one would go back to a cheap pavement merely because they were cheap. It should be the business of every manufacturer of paving brick to resist any effort to cheapen the foundation with a view of preserving the reputation and increasing the sale of his product.

The brick pavement is the most practical, the most economical known today, when it is laid right. It has had an uphill struggle to attain its present reputation, and was held back for years more on account of poor foundation than for any other cause. But now that we have the brick, the knowledge of how to apply the filler and other engineering data, the whole world will soon come to recognize the excellence of a brick covering."

In order to gain some idea of the extent to which vitrified brick have been used for street paving purposes in Indiana, their durability and the general satisfaction which they give, a letter was sent to the city engineer of each city in the State where brick pavements are in use, and a blank was enclosed to be filled out and returned.

From the replies received the following table has been compiled:

Statistics Concerning the Use of Vitrified Brick for Street Paving in Indiana.

Name of City.	Amount of Brick Pavements in Use.	Kind and Thickness of Foundations.	Average Cost Per Lineal Foot Each Side of Street.	Average Width of Street.	Total Number of Brick Used to Date.	Total Number of Block Used to Date.	Total Cost of Pavement.
Anderson, Madison County.	14.52 miles.....	Gravel, 8 inches; concrete, 6 inches, on 11,375 lineal feet.	\$4.24	30 feet.....	.....	.....	.....
Attica, Fountain County.	2,700 lineal feet.	Concrete, 6 inches.....	\$1.30 per square yard.	44 feet.....	.....	494,000	\$15,000
Bedford, Lawrence County.	9,660 lineal feet.	Concrete, 6 inches.....	\$2.83	25 feet.....	.....	1,315,200.....	\$54,189
Berne, Adams County....	3,960 lineal feet.	Crushed stone and gravel...	\$2.15	30 feet.....	.....	.....	\$30,452
Brazil, Clay County.....	5 miles	Concrete, 6 inches; sand, 2 inches; cinders and sand, 8 inches, used on several squares.	\$2.75	24 feet.....	.....	.....	\$145,200
Columbia City, Whitley County.	2½ miles	Crushed stone, 6 inches	\$2.46 for 28-foot street.	3 blocks, 71 feet; 3 bks, 56 feet; balance, 26 feet.	.....	.....	\$90,000
Columbus, Bartholomew County.	2,112 lineal feet.	Portland cement and gravel concrete, 6 inches.	\$2.37, \$1.57 per square yard.	30 feet, brick 27½ feet, cement gutter 16 inches.	.....	280,500	\$11,003
Connersville, Fayette County.	25,000 square yards.	Gravel and sand, 10 inches..	\$1.48 per square yard.	.....	.....	.....	\$40,000
Covington, Fountain County.	2,974 lineal feet.	Concrete, 8 inches on 1,264 feet; rolled road bed with 2-inch sand cushion on 1,710 feet.	\$1.50 with concrete, \$2.30 with sand cushion.	Concrete base 54 feet, sand cushion base 30 feet.	.....	.....	.....
Danville, Hendricks County.	1,440 lineal feet.	Crushed stone, 10 inches; sand, 2 inches.	\$1.36 per square yard.	50 feet.....	432,000 .....	.....	.....



The last Inspection of the Brick before the Application of the Filler.



Applying the Filler.

**ILLUSTRATING THE METHOD OF APPLYING CEMENT FILLER ON TERRE
HAUTE STREETS.**

Statistics Concerning the Use of Vitrified Brick for Street Paving in Indiana.

Name of City.	Places of Manufacture of Brick or Block.	Cost of Brick Per Thousand.	Cost of Block Per Thousand.	Durability of and Satisfaction Given by Brick Pavements.	General Remarks.	Authority.
Anderson, Madison County.	Ohio; mostly at Canton.	.....	.....	Brick pavements give much better satisfaction than those of wooden block.	.....	H. J. Wright, C. E.
Attica, Fountain County.	Veedsburg, Ind.....	.....	\$15.00	.....	"No other kind of pavement used except gravel."	Don Young, C. E.
Bedford, Lawrence County.	Athens, Ohio; Terre Haute, Ind.	.....	.....	Shows but little sign of wear and gives the best of satisfaction.	"Total cost includes grading, curbing and sidewalks except in one block."	.....
Berne, Adams County....	Canton, Ohio.....	.....	\$13.00	.....	.....	.....
Brasil, Clay County	Brasil, Indiana.....	.....	\$17.00	.....	.....	Geo. A. Fletcher, C. E.
Columbia City, Whitley County.	Canton, Ohio.....	.....	.....	Gives good satisfaction.....	"Brick pavements are to be preferred to asphalt in a town on heavily traveled streets."	A. N. Miller, C. E.
Columbus, Bartholomew County.	Veedsburg, Ind.....	.....	\$15.00 f. o. b. here.	Laid one year. Durability appears good; too noisy.	"Is not best for residence streets."	W. H. Rylla, C. E.
Connersville, Fayette County.	Canton, Ohio.....	.....	\$21.50	"Metropolitan" block have given good satisfaction and show fine surface with cement filler.	"Brick paving is superior to asphalt and better adapted for use in small cities."	J. Finan, Jr., C. E.
Covington, Fountain County.	Veedsburg, Ind.....	.....	.....	Pavement used nine years with no repair and as good as when laid.	.....	O. S. Jones.
Danville, Hendricks County.	Brasil, Ind.....	.....	.....	Has given good satisfaction.	.....	S. A. Entw.

Statistics Concerning the Use of Virgin Brick for Street Paving in Indiana—Continued.

Name of City.	Amount of Brick Pavements in Use.	Kind and Thickness of Foundations.	Average Cost Per Lineal Foot Each Side of Street.	Average Width of Street.	Total Number of Brick Used to Date.	Total Number of Block Used to Date.	Total Cost of Pavement.
Decatur, Adams County..	8,567 lineal feet.	Crushed stone with sand cushion, 8 to 12 inches.	.....	38 feet.....	475,000.....	950,000.....	\$58,413
Elkhart, Elkhart County.	4 29 miles.....	Gravel, 8 inches; crushed stone, 6 inches; screenings, 1½ inches; concrete, 4 inches.	\$3.64.....	37½ feet.....	.....	.....	\$165,530
Evansville, Vanderburgh County.	26 miles.....	Gravel concrete, 6 inches....	\$3.80, including curbing.	40 feet.....	36,600,000.....	.....	.....
Fairmount, Grant County.	14,270 lineal feet.	Gravel and sand, 10 inches....	\$2.75.....	26 feet.....	.....	1,860,000.....	\$78,285
Ft. Wayne, Allen County.	15.37 miles.....	(a) Broken stone, 6 inches; sand cushion, 2 inches. (b) Hydraulic cement concrete, 6 inches; sand cushion, 1 inch. (c) Portland cement concrete, 6 inches; sand cushion, 1 inch.	\$3.35.....	35 feet.....	Shale brick, 59,746 sq. re yards; fire clay brick, 8,579 square yards.	Shale block, 204,331 sq. re yards; fire clay block, 19,433 sq. re yards.	\$543,771
Fowler, Benton County...	1½ miles.....	(a) Gravel, 6 inches; sand, 2 inches. (b) Concrete, 4 inches; sand, 2 inches; gravel, 6 inches; sand, 1 inch.	30 feet wide \$1.50 50 feet wide \$2.50	30 feet and 50 feet.	.....	.....	.....
Frankfort, Clinton County.	10,800 lineal feet.	Concrete 8 inches.....	\$1.66.....	44 feet.....	2,401,000.....	.....	\$100,743
Franklin, Johnson County.	1 mile.....	Concrete, 6 inches; sand, 2 inches.	\$1.45.....	28 feet.....	.....	.....	\$20,000
Garrett, Dekalb County..	23,416 square yards.	Gravel and concrete.	\$4.01.....	40 feet.....	.....	23,416 square yards.	\$45,036



Example of First-class Brick Street, Fourteen Years in use.



Vitrified Brick Highway Bridge over Honey Creek, near Youngstown, Ind.

Statistics Concerning the Use of Vitrified Brick for Street Paving in Indiana—Continued.

Name of City.	Places of Manufacture of Brick or Block.	Cost of Brick Per Thousand sand.	Cost of Block Per Thousand sand.	Durability of and Satisfaction Given by Brick Pavements.	General Remarks.	Authority.
Decatur, Adams County.	Canton, Ohio; Veedersburg, Ind.	\$17.00 to \$24.00	\$18.00 to \$25.00	Very satisfactory in all ways except noise. No occasion to make repairs.	"Pavements are cleaned with steel hand scrapers during the entire year, except the dead of winter."	W. E. Fulk, C. E.
Elkhart, Elkhart County.	Canton and Malvern, Ohio.	\$18.50	\$19.16	Brick has preference over asphalt, as asphalt used here has been very poor.	"Prefer brick to asphalt."	C. R. Beardsley, C. E.
Evansville, Vanderburgh County.	Evansville, Ind.; Decatur, Ill.; Ironton and Sciotoville, Ohio.	\$13.00				Aug. Pfafflin, C. E.
Fairmount, Grant County.	Veedersburg, Ind., and Canton, Ohio.		\$18.00	Paved streets are giving the best of satisfaction.	"Standard or wire-cut blocks are very fine."	G. A. Fletcher, C. E.
Ft. Wayne, Allen County.	Canton, Ohio, and New Cumberland, W. Va.			Gives satisfaction when properly constructed.	"The most permanent pavement ever used in this city is of vitrified shale brick or block."	F. M. Randall, C. E.
Fowler, Benton County.	Veedersburg, Ind.					W. S. VanDer Voort, C. E.
Frankfort, Clinton County.						Chas. Hummel, C. E.
Franklin, Johnson County.	Brasil and Veedersburg, Ind.; Athens, Ohio.	\$18.00		Gives the best of satisfaction.		O. B. Sellers, C. E.
Garrett, DeKalb County.	Canton, Ohio.				Satisfactory in every respect.	

Statistics Concerning the Use of Vitrified Brick for Street Paving in Indiana—Continued.

Name of City.	Amount of Brick Pavements in Use.	Kind and Thickness of Foundations.	Average Cost Per Lineal Foot Each Side of Street.	Average Width of Street.	Total Number of Brick Used to Date.	Total Number of Block Used to Date.	Total Cost of Pavement.
Geneva, Adams County.	4,293 lineal feet.	Crushed stone, 8 inches; gravel, 4 inches.	\$5.02	30 feet.	.....	680,000	\$46,000
Goshen, Elkhart County.	2 miles	Gravel, 10 inches.	\$3.48	50 feet.	2,685,000	.....	\$73,500
Hammond, Lake County.	9,600 lineal feet.	Roller stone, 8 inches.	\$1.65 per square yard.	40 feet.	.....	.....	.....
Hartford City, Blackford County.	23,569 lineal feet.	(a) Concrete, 6 inches on 74,403 square yards. (b) Crushed stone, 6 inches on 9,887 square yards.	\$4.33	32 feet.	.....	3,520,000	\$204,195
Huntington, Huntington County.	6½ miles	Broken stone and sand, 8 inches.	\$2.00	30 feet.	.....	5,390,000	\$168,300
Jasonville, Greene County.	1,680 lineal feet.	Portland cement concrete, 9 inches.	\$4.82	36 feet.	6,720 square yards.	.....	\$16,195
Jeffersonville, Clark County.	2,033 lineal feet.	Concrete, 6 inches.	\$2.95	40 feet.	320,000	227,000	\$18,611
Kendallville, Noble County.	1,268 lineal feet.	Concrete, 6 inches	\$5.53	50 feet.	.....	.....	\$14,024
Knox, Starke County.	2,640 lineal feet.	Yellow sand	\$1.73 on 26-foot st. \$2.42 on 46-foot street	26 and 46 feet	.....	.....	.....
Kokomo, Howard County	4.45 miles	Crushed stone and stone dust rolled solid and flooded white rolling.	\$2.50 on old macadam; \$3.49 on new foundation.	30 feet.	.....	3,572,000	\$121,972

Statistics Concerning the Use of Vitrified Brick for Street Paving in Indiana—Continued.

Name of City.	Places of Manufacture of Brick or Block.	Cost of Brick Per Thousand.	Cost of Block Per Thousand.	Durability of and Satisfaction Given by Brick Pavements.	General Remarks.	Authority.
Geneva, Adams County.	Canton, Ohio.	.....	\$20.50.....	.....	.....	J. H. Kelley.
Goshen, Elkhart County.	Canton, Ohio; Veedersburg, Ind.	\$18.00.....	.....	Has given good satisfaction.	.....	J. L. Cooper, C. E.
Hammond, Lake County.	Brazil, Ind.	.....	.....	.....	In service three years, satisfaction good.	P. J. Lyons, C. E.
Hartford City, Blackford County.	Logan, Canton, Nelsonville and Roseville, Ohio.	.....	.....	First street laid, in 1895, is in a good state of preservation and very satisfactory. Three miles of cedar block pavement, laid at same time, relaid with brick in 1904.	Cost per foot given include all cost in connection with work of putting in improvements.	Wm. Harley, C. E.
Huntington, Huntington County.	.....	.....	\$18.50.....	"First block pavement, laid in 1893, is in perfect condition."	.....	H. H. Waggoner, C. E.
Jasonville, Greene County.	Brazil, Ind.	.....	\$22.00.....	.....	.....	Jno. C. Wells.
Jeffersonville, Clark County.	Brick, New Albany, Ind.; block, Louisville, Ky., and New Cumberland, W. Va.	\$10.50.....	\$15.00.....	.....	"Vitrified block is much better and cheaper than macadam."	V. W. Lyons, C. E.
Kendallville, Noble County.	Canton, Ohio.	.....	\$16.10.....	.....	.....	W. Sawyer, C. E.
Knox, Starke County.	Streator, Ill.	.....	.....	Pavement laid in 1898, satisfaction good.	.....	Omar A. Garner.
Kokomo, Howard County.	Veedersburg, Brazil and Clinton, Indiana, and Canton, Ohio.	.....	\$17.00 f.o.b. Kokomo.	Give good satisfaction; for durability nothing equals brick for the cost.	For small cities brick pavements are the cheapest, their most serious objections are noise and slipperiness.	W. F. Mann, C. E.

Statistics Concerning the Use of Vitrified Brick for Street Paving in Indiana—Continued.

Name of City.	Amount of Brick Pavements in Use.	Kind and Thickness of Foundations.	Average Cost Per Lineal Foot Each Side of Street.	Average Width of Street.	Total Number of Brick Used to Date.	Total Number of Block Used to Date.	Total Cost of Pavement.
Lafayette, Tippecanoe County.	9,680 lineal feet.	(a) Gravel on rolled sub-grade, 18 to 12 inches. (b) Portland cement concrete, 6 inches.	\$3.30.....	40 feet.....	47,000 square yards.	15,000 square yards.	\$106,000
Laporte, Laporte County.	5,122 lineal feet.	Concrete, 4½ inches; sand, 2 inches.	.....	46 feet.....	.....	.....	.....
Lawrenceburg, Dearborn County.	820 lineal feet.	Hydraulic cement concrete, 6 inches.	\$3.10.....	42 feet.....	.....	.....	.....
Lebanon, Boone County.	2.7 miles.....	(a) Portland cement concrete, 6 inches; sand, 1 in. (b) Gravel, 10 inches. (c) Broken stone, 10 inches.	\$3.25.....	30 feet.....	250,000.....	2,100,000.....	.....
Ligonier, Noble County.	1,800 lineal feet.	Sand and gravel.....	\$2.77.....	30 feet.....	.....	.....	\$10,000
Logansport, Cass County.	2.15 miles.....	Concrete, 6 inches.....	\$4.75.....	66 feet.....	.....	.....	.....
Madison, Jefferson County.	337 lineal feet.	Gravel, 12 inches, rolled....	\$3.54.....	40 feet.....	81,000.....	.....	\$2,392
Marion, Grant County...	18.4 miles....	(a) Concrete, 6 inches..... (b) Crushed stone, 8 inches. (c) Gravel, 10 and 12 inches.	\$3.50.....	30 feet.....	.....	305,475 square yards.	\$623,501

Statistics Concerning the Use of Vitrified Brick for Street Paving in Indiana—Continued.

Name of City.	Places of Manufacture of Brick or Block.	Cost of Brick Per Thousand.	Cost of Block Per Thousand.	Durability of and Satisfaction Given by Brick Pavements.	General Remarks.	Authority.
Lafayette, Tippecanoe County.	Clinton and Veedersburg, Ind.	.....	.....	Vitrified block on concrete base, put down at same time as asphalt is in much better shape.	.....	.....
Laporte, Laporte County.	Canton, O.; Clinton and Veedersburg, Ind.	.....	.....	.....	Perfectly satisfactory.	L. E. Daniels.
Lawrenceburg, Dearborn County.	Portsmouth, Ohio.	.....	.....	.....	.....	A. T. Gridley, C. E.
Lebanon, Boone County.	Canton, O.; Terre Haute, Veedersburg, Clinton, Crawfordville, Brazil, Indiana.	\$16.00	\$18.00	"Brick pavements are the best and most economical. Our tax-payers will hear of nothing else."	"The ideal pavement for cities under 10,000 is of brick 20 to 25 feet wide in resistance portion and 38 feet wide on business streets."	Jno. W. Fulwider, C. E.
Ligonier, Noble County.	Canton, Ohio	.....	\$20.00	Vitrified block pavement, laid 5 years; gives good satisfaction; a little noisy.	"Much better than wooden blocks."	E. B. Gerber, C. E.
Logansport, Cass County.	Veedersburg, Terre Haute, Clinton and Crawfordville, Ind.	.....	.....	Much more satisfactory than asphalt.	.....	.....
Madison, Jefferson County.	Portsmouth and Sciotoville, Ohio.	\$16.00	.....	.....	Mr. Grimes, C. E., of Terre Haute, has succeeded in using a cement filler to the best advantage. This has much to do with the lasting qualities of a brick street.	W. B. Ray, C. E.
Marion, Grant County.	Veedersburg, Brazil and Crawfordville, Ind.; Canton and Logan, Ohio.	.....	.....	More durable and satisfactory than asphalt.	.....	Thos. Petrie, C. E.

Statistics Concerning the Use of Vitrified Brick for Street Paving in Indiana—Continued.

Name of City.	Amount of Brick Pavements in Use.	Kind and Thickness of Foundations.	Average Cost Per Lineal Foot Each Side of Street.	Average Width of Street.	Total Number of Brick Used to Date.	Total Number of Block Used to Date.	Total Cost of Pavement.
Martinsville, Morgan County.	2,000 lineal feet.	Portland cement and gravel concrete, 6 inches.	\$2.25	25 feet.....	.....	35,000	\$20,000
Michigan City, Laporte County.	11.31 miles ...	Crushed stone concrete, 5 inches.	\$2.25	66 feet.....	1,880,000	5,400,000	\$260,000
Mishawake, St. Joseph County.	1,560 lineal feet.	Gravel	\$2.80	36 feet.....	.....	287,000	\$14,000
New Albany, Floyd County	One block....	Concrete, 6 in.....	\$3.52 .....	.....	.....	.....	.....
Noblesville, Hamilton County.	9,850 lineal feet.	Gravel, 10 inches; sand, 2 inches.	\$3.50	40 feet.....	.....	2,600,000	\$45,000
Peru, Miami County	3,172 lineal feet.	Crushed stone concrete, 6 inches.	\$6.35	64 feet.....	.....	23,012 square yards.	\$40,271
Plymouth, Marshall County.	9,246 lineal feet.	(a) Concrete, 5 or 6 inches; sand cushion, 2 inches; (b) Rolled gravel, 6 inches; sand cushion, 2 inches.	\$3.60	40 feet.....	.....	1,889,000	\$66,381
Russelslaer, Jasper County.	1,050 lineal feet.	Macadam, 6 inches	\$5.50	55 feet.....	.....	.....	\$11,700
Richmond, Wayne County	1½ miles	(a) Crushed stone, 8 inches; (b) Concrete, 6 inches.	\$5.12	42 feet.....	1,700,000	560,000 .....	.....
Rochester, Fulton County	3,770 lineal feet.	Concrete, 6 inches; sand, 2 inches.	\$5.06	52 feet.....	.....	1,000,000	\$50,240
Seymour, Jackson County	3,023 lineal feet.	Hydraulic cement concrete, 6 inches.	\$1.06 for 54 feet in width. \$3.00 for 36 feet in width.	54 to 36 feet.....	.....	670,000	\$21,194

Statistics Concerning the Use of Vitrified Brick for Street Paving in Indiana—Continued.

Name of City.	Places of Manufacture of Brick or Block.	Cost of Brick Per Thousand.	Cost of Block Per Thousand.	Durability of and Satisfaction given by Brick Pavements.	General Remarks.	Authority.
Martinsville, Morgan County.	Veedersburg, Ind .....	.....	\$20.00	Best of satisfaction	"Difficult to improve any more streets without brick."	H Johnson, C. E.
Michigan City, Laporte County.	Brazil and Veedersburg, Ind.; Canton and Zanesville, Ohio.	\$13.00	\$18.00	Vitrified brick, most durable and economical of all pavements.	.....	H. M. Miles, C. E.
Mishawaka, St. Joseph County.	Brazil, Ind. ....	.....	\$20.00	Very satisfactory	Brick is better adapted to business streets, but asphalt or bitulithic pavement is preferable for residence streets.	Wm S. Moore, C. E.
New Albany, Floyd County.	New Albany .....	.....	.....	.....	.....	E. B. Coolman, C. E.
Noblesville, Hamilton County.	Veedersburg, Terre Haute and Brazil, Ind.	.....	\$18.50	Satisfaction fair .....	.....	J. F. Shannon, C. E.
Peru, Miami County	Canton, Ohio. ....	.....	.....	.....	.....	H. L. Hall, C. E.
Plymouth, Marshall County.	Crawfordsville and Clinton, Ind.	.....	\$16.50 .....	.....	"Sentiment strongly in favor of brick pavements. No use to propose any other."	J. C. Butler, C. E.
Ransselaer, Jasper County.	Brazil, Ind. ....	.....	.....	Streets laid in 1901. No apparent wear to date.	.....	H. L. Gamble, C. E.
Richmond, Wayne County.	Canton, Ohio	\$14.00	\$20.00	Pavements as good as when laid 6 to 13 years ago. Have not cost one cent for repairs, and will not for the next ten years.	.....	H. L. Weber, C. E.
Rochester, Fulton County.	Crawfordsville, Ind. ....	.....	.....	Finished October, 1904	Cost includes curb and marginal curb	Vernon Gould.
Seymour, Jackson County	Athens, Ohio; Brazil, Ind.	.....	\$13.00	In use 9 years. From a sanitary view has no superior. Noise only objection.	"Cost includes pavement and curb."	Geo. Stagle, C. E.

Statistics Concerning the Use of Vitrified Brick for Street Paving in Indiana—Continued.

Name of City.	Amount of Brick Pavements in Use.	Kind and Thickness of Foundations.	Average Cost Per Lineal Foot Each Side of Street.	Average Width of Street.	Total Number of Brick Used to Date.	Total Number of Block Used to Date.	Total Cost of Pavement.
South Bend, St. Joseph County.	27.66 miles ...	(a) Concrete, 6 inches; (b) Gravel, 6 inches.	\$2.55	38 feet	3,800,000	21,934,000	\$745,990
Terre Haute, Vigo County.	9½ miles	(a) Concrete, 6 inches. (b) Crushed stone, 6 inches.	\$3.50	35 feet	8,000,000	2,000,000	\$350,000
Tipton, Tipton County..	7 miles	Gravel, 8 inches; sand, 2 inches.	\$4.00	30 feet .....	.....	4,928,000	\$395,680
Union City, Randolph County.	3,168 lineal feet.	Broken stone and gravel....	\$6.49	48 feet .....	.....	.....	\$46,000
Valparaiso, Porter County.	1.1 miles	Sand, 12 inches	\$2.85	30 feet .....	.....	648,000	\$32,040
Veedersburg, Fountain County.	1.12 miles ...	(a) Concrete, 6 inches. (b) Gravel, 8 inches	\$4.00	32 feet	200,000	900,000	\$23,320
Wabash, Wabash County.	1.25 miles ...	Crushed stone, 12 inches ...	\$2.95	13 feet	350,000 .....	.....	.....
Warsaw, Kosciusko County.	6,080 lineal feet.	Gravel and sand, 6 to 10 inches.	\$2.30	50 feet .....	.....	1,400,000	\$60,000
Washington, Daviess County.	16,451 lineal feet.	Concrete, 6 inches	\$3.17	30 feet	836,000	3,320,000	\$104,460
Windfall, Tipton County.	5,298 lineal feet.	Gravel and sand, 10 inches..	\$2.60	28 feet .....	.....	.....	\$32,000

Name of City.	Places of Manufacture of Brick or Block.	Cost of Brick Per Thousand.	Cost of Block Per Thousand.	Durability of and Satisfaction Given by Brick Pavements.	General Remarks.	Authority.
South Bend, St. Joseph County.	Brazil, Veedersburg, Crawfordsville, Clinton, Terre Haute and South Bend, Ind.; Danville and Streator, Ill.; Canton, etc., Ohio.	.....	\$21.00, f.o.b. South Bend.	Brick pavements proving more durable than asphalt, and the comparative mileage, 27.66 to 4.33, gives an idea of the satisfaction.	.....	A. J. Hammond, C. E.
Terre Haute, Vigo County.	Clinton, Veedersburg, and Terre Haute, Ind.; Canton and Wooster, Ohio.	\$17.00	\$17.00	Where construction was properly made, no repairs have been necessary on account of wear, and none are likely for several years.	.....	W. P. Blair.
Tipton, Tipton County.	Canton, Logan and Carroll, Ohio; Crawfordsville, Ind.	.....	\$18.00 .....	.....	"On account of empty car movement from east to west, Ohio shippers obtain a better rate in here than Indiana shippers."	R. M. Vanbuskirk.
Union City, Randolph County.	Canton, Ohio	.....	.....	.....	Laid in 1903	S. R. Bell, C. E.
Valparaiso, Porter County.	Zanesville and Athens, Ohio.	.....	.....	.....	.....	A. R. Putnam, C. E.
Veedersburg, Fountain County.	Veedersburg, Ind.	\$13.00	\$13.00	Satisfaction, good .....	.....	.....
Wabash, Wabash County.	Canton, Ohio; Veedersburg, Ind.; Danville, Ill.	\$19.50 .....	.....	.....	"No streets laid. Accompanying data refers to alleys."	Jno. Hilty, C. E.
Warsaw, Kosciusko County.	Canton, Ohio.	.....	.....	.....	Laid in 1904	Geo. W. McCarter, C. E.
Washington, Daviess County.	Evansville, Ind.; Athens, Ohio.	.....	.....	Good. Pavements have been down 6 to 10 years. Not 6 cents worth of repairs so far, except on the first 9 squares, where curbing was not what it should have been.	.....	Thos. J. Smiley, C. E.
Windfall, Tipton County.	Veedersburg, Ind.	.....	.....	.....	.....	.....

Paving Brick Factories of Indiana.—Six large factories in Indiana are now engaged exclusively in the making of vitrified brick or block for street paving purposes. Five of these, viz., the Terre Haute Brick & Pipe Co., at Terre Haute; the Indiana Paving Brick & Block Co., at Brazil; the Wabash Clay Co., at Veedersburg; the Clinton Paving Brick Co., at Clinton, and the Evansville Pressed Brick Co., at Evansville, are using the Carboniferous shales, and one, the Poston Paving Brick Co., at Crawfordsville, the Knobstone shale.

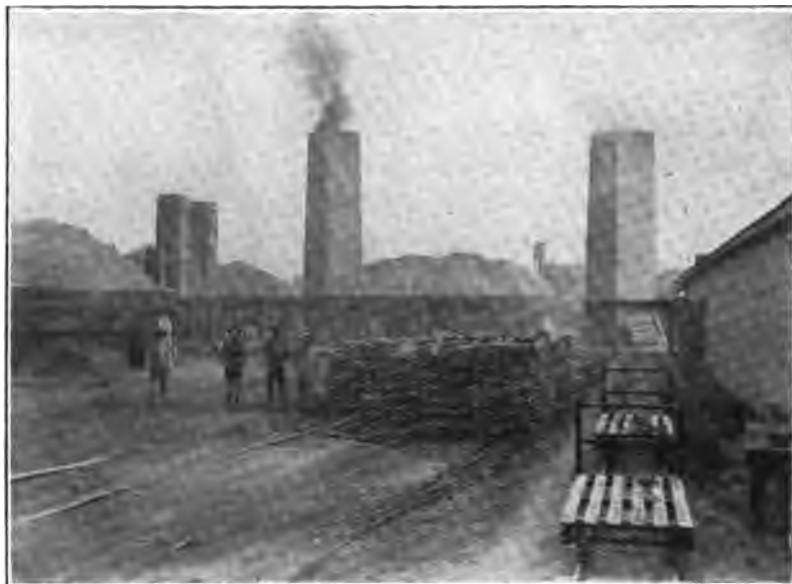
The plant of the Poston Company is the newest and most modern one of the six. It covers about six acres, and consists of a boiler house, a power house, machine room, drier, fan house and office, all with brick walls and slate roofs, so that no insurance is carried. A plentiful water supply is obtained from a driven well. 209 feet in depth. The shale used comes from a point about one and a fourth miles to the north, and has been described in a preceding section, on page 343.

On arriving at the plant the cars of shale stand on the unloading track above the dry pan. For winter operations a steaming house has been constructed, and in severe cold weather a car of shale is stopped in the steam house, heavy canvas curtains at the ends are dropped, and a jet of steam is forced under the shale through perforations in the sides of the car, thus thawing out the shale in readiness for shovelers at the dry pan below. The larger pieces of shale are run through a Joplin ore crusher and then conveyed by belt conveyor to the dry pan.

The plant is equipped with Raymond machinery throughout, comprising one Raymond 9-foot dry pan, of 150 tons daily capacity; a "777" auger stiff mud machine, a pug mill, Triumph cutter, two Victor represses and a complete equipment of steel single-deck drier cars.

Power is derived from a 250-horsepower Bates-Corliss engine and 200-horsepower Chandler-Taylor boiler, fitted with a Jones under-feed stoker. A steam pressure of 85 pounds is maintained. The boiler stack is of brick of square shape and 50 feet high. Both forced and induced drafts are used.

The drier has eight tunnels utilizing waste heat. It was formerly a direct heat drier, and now the waste heat enters the former fireholes, passing upward into and through the drier to a 50-



Down the Yard, showing the 30-foot Round Down-draft Kilns.



The "Setting" Gang and Car of Green Poston Block, ready to set.
TWO VIEWS AT THE PLANT OF THE POSTON PAVING BRICK COMPANY.

foot brick stack at the upper end. From 30,000 to 35,000 10-pound blocks are dried in 24 hours. Each track of the drier holds 15 cars, and each car 337 blocks. A five-foot exhaust fan is used at one end to draw moisture and cause circulation in the tunnel, while a 12-foot fan is used to pull the hot air from the kilns and force it through the tunnels leading to the drier. This process is begun within two hours after the burning is completed, and a saving of \$10 a day for fuel over the old method of drying by direct heat is thus effected.

The burning is done in eight 30-foot and four 26-foot round, down-draft kilns. Each kiln has ten 22-inch fire holes, with slanting grate bars. Burning is accomplished in eight days, and no black-cored brick are to be seen on the yard. More care, however, has to be taken in burning than with similar wares made from the Carboniferous shales. The heat cannot be varied over 50 to 75 degrees without causing large numbers of the block to shrink, double or crack. From 67 to 72 per cent. of firsts are gotten from each kiln. These were selling, in June, 1904, at \$15 per thousand. The "seconds" were bringing \$9.00 for rock-faced building purposes, and the company at that time were 600,000 behind in its orders for them.

By the new process of cooling and drying, only 12 to 13 days are required from the time the shale enters the dry pan until the block are ready to load on the car. Coke is used for water-smoking and Rosedale screened lump coal, costing \$1.94 per ton laid down, for burning, about one and a third tons of the latter being required for each thousand block. Four kilns are attached to one stack. The stacks are all square, 35 feet high and webbed about two-thirds of the way up.

Work is carried on all the year through with ease, as the peculiar nature of the material is such that, wet or dry, hot or cold, it remains practically the same, never clogs the screens, and is easily steamed or thawed in the coldest weather.

Recent tests made in Kalamazoo, Mich., Maywood, Ill., and St. Louis, Mo., have demonstrated that the Poston block from Knobstone shale is one of the best pavers made in the middle West. The results of the St. Louis test, made October 7, 1902, showed as follows:

Results of Tests made on Poston Paving Block, 9x4x3 1-2 Inches in Size by the Testing Department of the St. Louis Street Commission.

(a) Number of brick tested.....	32
(b) Impact and abrasion, per cent. loss (required not more than 25 per cent.).....	16.17
(c) Cross breaking, modulus of rupture (required not less than 2,000 pounds average).....	2,910
(d) Absorption, per cent. (allowed 4 per cent. in 48 hours).	3.73
(e) Specific gravity	2.18

Tests of the crushing strength made at Purdue University by Prof. W. K. Hatt resulted as follows:

Method of Test.—A half brick was tested on edge and another half brick was tested on its face. Both samples were bedded in plaster of paris.

Results.

	<i>Crushing strength per sq. in. of bed.</i>
Half brick on edge.....	13,600 pounds.
Half brick on face.....	14,540 pounds.

The results here given show that under the proper management vitrified brick of the highest grade can be made from the Knobstone shale of Indiana.

The plant of the Terre Haute Brick & Pipe Co. is located on the west side of the Wabash River, two and a half miles northwest of Terre Haute. The material used is from the noted bed of Carboniferous shale overlying coal VII (see page 160). It is dumped into chutes leading to two nine-foot dry pans, so that but one man is needed to each pan. From there it is elevated to a gravity screen, where the clay from the two pans is mixed. The mixture then passes through a 12-foot pug mill into a new 999 Raymond machine, with a Raymond rotary automatic cut-off attached. Two Bonnot represses are used when the order calls for repressed brick, an extra charge of \$1.00 per thousand being added for repressing. Since 1902 the waste heat process of drying has been used, the company being the first one in Indiana to adopt this system. A 12-foot American blower intake fan and an 8-foot Crawford & McCrimmon exhaust fan are connected with the drier. The latter is a 110-foot, 15-track tunnel, covered with four inches of concrete. The drying cars, 210 in number, each hold 500 brick, the drying being done in 36 hours. The burning is done in two 28-foot and 13 30-foot standard round down-draft kilns, and takes from nine and a half to ten days, mine run coal from the company's land being used as fuel.



Hauling up the Shale.



Dumping the same.



Loading Brick for shipment.

SNAP SHOTS AT THE FACTORY OF THE TERRE HAUTE BRICK
AND PIPE COMPANY.

The power is derived from a 400-horsepower Bates-Corliss engine and battery of four boilers. The engine is set on a foundation 14 feet thick, made of pavers. All the machinery about the plant is well adjusted, so that there is little noise and a minimum of unnecessary wear.

The brick made by the company are, after burning, $4 \times 8\frac{1}{2} \times 2\frac{1}{2}$ inches in size and weigh seven pounds. About 70 per cent. No. 1 brick, which are sold for pavers, are gotten from each kiln. They bring about \$15 per thousand for block and \$12.00 for brick, while the seconds, sold for foundation and superstructure work purposes bring \$9.75 and \$7.75 per thousand. The brick from this factory have been used in the streets of many of the cities and larger towns of Indiana, Illinois, Michigan and Ohio, and have given eminent satisfaction wherever tried. They burn to a handsome dark reddish brown color on the surface, while within they are dark cherry red.

That these brick are of excellent quality is shown by the following tests made by Prof. M. A. Howe, of the Rose Polytechnic Institute, for George H. Simpson, city engineer of Terre Haute, who attempted to select average (not the best) bricks for the test. The bricks were supported on rounded knife edges six inches apart and force applied through a knife edge acting midway between supports. One brick with a cross section of 2.37×4 inches and another of 2.44×4 inches, when lying on the side, showed a cross-breaking strength of 2,630 and 2,240 pounds per square inch, respectively. In another test, brick from the same factory had a breaking strength of 2,720, 2,780, 3,360, 1,820, 2,170, 2,310 and 3,530 pounds per square inch. A brick from the river bottom clay, subjected to the same test, showed a cross-breaking strength of 1,440 pounds per square inch.

Subjected to the absorption test, brick made by the same company showed, after forty-eight hours in water, .7, .7 and .22 per cent. of absorption, while brick from the alluvial clay showed 4.34 per cent. These tests showed that the Carboniferous shale of Vigo County, overlying coal VII, will make paving brick of the highest quality.

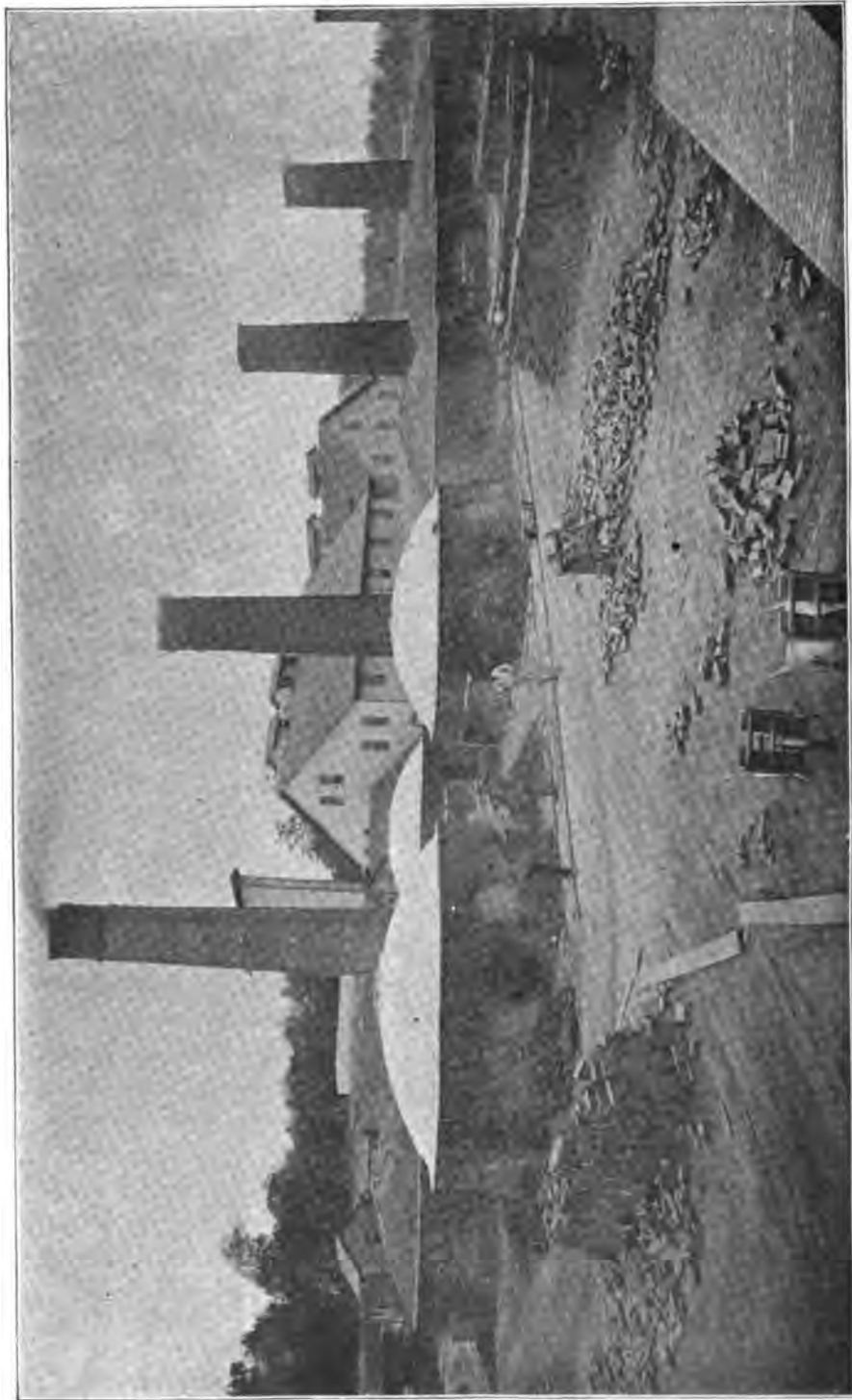
The plant of the Indiana Paving Brick Co., in the western suburbs of Brazil, is the oldest in Indiana, having been erected in 1891. The shale used in making their product (see page 192) is

dumped either from railway or tram cars by the side of three dry pans, respectively seven, eight and nine feet in size. After being ground in these it is elevated and passed over two 15-foot gravity screens into a 16-foot pug mill. From here it is made into pavers on a Freese auger machine, these being repressed on three double repress machines.

The drying is done by the waste heat process, this being substituted for the old steam system in 1903. The change cost about \$5,000, and was effected by reroofing the old drier with concrete and constructing a system of 7-foot underground tunnels between the kilns and drier. But one fan is used, the heat and moisture leaving the drier through flues connected with each double track tunnel. The new process saves at least \$2,000 a year in fuel. With it a temperature of 270 degrees F. is readily maintained. The drying is accomplished in 24 hours, as against 36 by the old process. The kilns are cooled in five days, whereas it formerly took seven to eight days. The burning is accomplished in twenty 28 and 30-foot kilns, which hold an average of 36,000 block each. The water-smoking and burning occupy 12 days. Seeleyville bituminous lump and slack coal is used, the former costing \$1.35 and the latter 75 cents per ton, laid down, these prices prevailing in July, 1904, at all Brazil factories which did not mine their own coal. Two cars of lump at the kilns and ten tons of slack for the boilers represent the average daily amount used. Fifty tons of coal, on an average, are required in burning each kiln of 36,000 paving block. Lake Michigan sand, costing \$1.00 per ton at the plant, is used in setting the brick, a forty-ton car lasting six weeks.

The plant is operated with a 150-horsepower engine and battery of five boilers. By forcing a mixture of steam and air into the furnaces, much of the smoke is consumed and a saving of fuel effected. About 100 men are employed in the pits and at the plant, the average wage running about \$1.70 per day. The average output of the factory is 36,000 paving block, $3\frac{1}{4} \times 4 \times 9$ inches in size, per day of ten hours. When green, these block weigh ten pounds; after burning, nine pounds each.

Tests of the burned block, made by the testing department of the St. Louis Street Commission, September 2, 1902, resulted as follows:



Works of the Wabash Clay Company, Veedersburg, Fountain County.

day. This output averages 80 per cent. firsts, which, in June, 1904, were selling for \$13.50 per thousand. The seconds are sold mainly for rock-faced building purposes. During the winter season about half a million special sidewalk brick are made, which bring \$15.00 per thousand at the plant. A special gutter block, 5x4x10 inches, which weigh 17 pounds each, are also made as ordered. The storing sheds hold shale enough for only four days' run, yet during the severe winter of 1903-4 but one day was lost. About 110 men are employed, mostly by piecework, making an average of about \$1.75 per day. Burners receive \$2.10 per day of 12 hours.

Hundreds of millions of Poston and Culver block from the factory of the Wabash Clay Co. have been used in the cities and towns of Indiana, Illinois and Michigan during the past ten years. Everywhere they have given the best of satisfaction, and they are generally recognized as a standard material for paving purposes.

The plant of the Clinton Paving Brick Co. was erected in 1893, a short distance northwest of Clinton, Vermillion County. The shales used have been already described (see page 147). They are hauled by tram car from the pit and dumped by the side of a 9-foot dry pan. After grinding the material is elevated and passed over a 12-foot rotary screen. From this it enters a 9-foot pug mill and is then made into pavers on a Penfield No. 10 side-cut auger machine, with automatic cut-off attached. Two Columbia represses are in use, after passing through which the block are dried by waste heat in a progressive drier containing two five-track tunnels holding 15 cars each, the drying taking about 24 hours. Ten days are required for the burning, which is done in square Eudaly down-draft kilns, eight of which, holding 90,000 block each, are in use.

The daily output of the plant averages 31,000 block, 3 $\frac{3}{4}$ x4x9 inches in size. These are tough, compact block, neither brittle nor "glassy," and with a much smoother surface than is usually seen in similar wares. For eleven years these block have been sold in the leading towns and cities of Indiana, Michigan and Illinois, and have everywhere given the best of satisfaction. Many of the places have laid pavements of the Clinton brick or block in three or more different years. For example, streets in Lafayette, Ind., were paved with these block in 1895, 1896, 1897, 1899, 1900 and

1901. This in itself is sufficient to prove the esteem in which the block are held wherever they have once been used.

The plant of the Evansville Pressed Brick Co., which is now making only pavers from the shale described on page 311, is situated in the northwestern environs of the city of Evansville. The shale is hauled from the pit in wagons and either stored in sheds or dumped by the side of a 9-foot dry pan. The sheds hold enough to run two and a half months, and are usually filled for winter use. After grinding, screening and pugging, the pavers are made on a Chambers end-cut auger machine, with automatic cut-off attached, and repressed on two Penfield represses. The drying occupies 48 hours, and is done in two 4-track progressive tunnels by steam.

Burning is done in six square down-draft kilns, holding about 90,000 each, and requires 11 to 12 days. Evansville mine run and pea and slack coal, costing from \$1.00 to \$1.25 per ton, is used as fuel. An Atlas 90-horsepower engine and battery of three boilers furnishes the power. About 75,000 No. 1 street brick are secured from each kiln. These were sold in 1904 for \$12.00 per thousand f. o. b. at the plant. The seconds are mostly used for alleys and sidewalks, and bring \$9.00 per thousand. The brick made by this company are sold mostly in southern Illinois and in the cities along the Ohio River. Wherever used they have proven tough and durable, and have given the best of satisfaction.

In addition to the paving brick factories already described, another completed in 1904 is ready for operation, namely, that of the Veedersburg Clay Co., at Veedersburg, Fountain County. The plant is well equipped with machinery, mainly that of the Bonnot Co., of Canton, Ohio, consisting of two 9-foot dry pans, oscillatory double screen, "Dewey" stiff mud side-cut auger machine, with automatic cut-off; two double represses and 160 double-deck steel cars. Drying will be done by waste heat in an eight-tunnel drier and burning in twelve 28-foot round down-draft kilns. A 200-horsepower June engine furnishes the power. The output will consist of vitrified paving and sidewalk brick and ordinary stiff mud building brick made from shale.

The following table has been prepared, which gives, in condensed form, the principal statistics of the paving brick factories at present operating in Indiana:

Statistics of Indiana Paving Brick Factories for the Year 1904.

NAME OF FIRM.	Location.	Began Operat- ing.	Capital Invested.	Product.	System of drying.	Number and kind of kilns.	Total kiln capacity.	No. hands em- ployed.	Average daily wages.	Output in 1904	Value of out- put for 1904.	No. of months worked.
Poston Paving Brick Co.	Crawfordsville, Montgomery County.	1901	\$50,000	Poston Paving Block, $3\frac{1}{2} \times 4 \times 9$ inches.	Tunnel dryer by waste heat.	4 28-foot and 8 30- foot round down draft.	380,000 Block.	60	\$1 70	6,000,000 Block.	\$80,000	10½
Terre Haute Brick and Pipe Co.	Terre Haute, Vigo County.	1885	120,000	Paving brick, $2\frac{1}{4} \times$ 4×9 inches.	Tunnel dryer by waste heat.	2 28-foot and 13 30- foot round down draft.	600,000 Brick.	50	1 75	6,000,000 Brick.	60,000	10
Indiana Paving Brick and Block Co.	Brazil, Clay County.	1891	70,000	Paving block, $3\frac{1}{2} \times$ 4×9 inches.	Tunnel dryer by waste heat.	6 28-foot and 14 30- foot round down draft.	720,000 Block.	100	1 70	10,000,000 Block.	110,000	12
Wabash Clay Co.	Veedersburg, Fountain County.	1892	100,000	Paving block, $4 \times$ $3\frac{1}{2} \times 9$ inches. Sidewalk brick. Gutter block.	Tunnel dryer by waste heat.	25 28-foot round down draft.	625,000 Block.	110	1 75	14,521,000 Block.	159,721	12
Clinton Paving Brick Co.	Clinton, Vermil- lion County.	1893	60,000	Paving block, $8\frac{1}{2} \times$ 4×9 inches.	Tunnel dryer by waste heat.	8 Square Endaly down draft.	720,000 Block.	60	1 65 for 9% hrs.	8,294,000 Block.	91,000	11½
Evansville Pressed Brick Co.	Evansville, Vanderburgh County.	1890	44,000	Paving brick, $2\frac{1}{2} \times$ 4×8 inches.	Progressive, 2 4- track tunnels, by steam.	6 Square down draft.	540,000 Brick.	40	1 75	3,500,000 Brick.	38,000	10
Veedersburg Clay Co.	Veedersburg, Fountain County.	1904	60,000	Paving block. Sidewalk brick, etc.	Progressive, 8- track tunnel by waste heat.	12 28-foot round down draft.	325,000 Block.	45	1 65	1,000,000 Block.	10,000	5
Totals.....			\$504,000					465		49,706,000	\$545,721	

II. THE MANUFACTURE OF SEWER PIPE AND KINDRED HOLLOW WARES.

Under this head is included the making of sewer pipe, conduits, hollow building brick and block, chimney tops, flue linings, terra cotta lumber, fireproofing, vitrified drain tile and all hollow products of similar grade. Of the wares mentioned, the sewer pipe, conduits and hollow building brick are vitrified in the making. The others are burned at a lower temperature, generally for a shorter time, and are not salt-glazed, as are the vitrified products.

With the exception of the terra cotta lumber and fireproofing industry, which use silty or marly surface clays, the clays used are the same as for making paving brick, i. e., mainly the under-clays and shales of the Coal Measures. In the beginning of the hollow goods industry in Indiana only the under-clays were used, but as the business increased it was found that wares made of the shales were of excellent grade, and that there is less loss in drying and burning than where similar products are made of under-clays exclusively. As a result, most of the newer factories have utilized the shales, so that of the 16 factories now in operation, eight use shales, six principally under-clays, and two silty or marly clays.

The securing and preparation of the clays for making hollow goods is by essentially the same processes as those used in the making of paving brick (see page 527). The wet pan is most used in tempering, and the latter process is, therefore, more thorough than can be accomplished in a pug mill.

A machine known as the sewer pipe press is the one universally used in the making of sewer pipe and also for many kinds of hollow wares. It is a modification of the "plunger" brick machine previously mentioned, and consists of two cylinders placed upright, one above the other, and separated by a heavy cast-iron frame, to which the cylinder heads are bolted. The upper or steam cylinder is usually 40 inches in diameter, and the lower, or clay cylinder, 18 inches. The piston rod is made either single or triple, and is continuous from the clay piston to the steam piston. The clay piston is a cast-iron head, which can be replaced easily when worn. Steam pressure is used in operating the machine,

and is controlled by a lever from the level of the working platform.

Seven or eight men constitute the "press gang" necessary to operate the machine and remove the pipe as fast as made to the dry floors. The size of the sewer pipe varies from four inches in diameter to 36 inches, or even larger, but the sizes most used range from 8 to 20 inches. As fast as made they are cut to the desired length, and each is set upright on a wooden pallet of appropriate size. These pallets are then placed on trucks and taken to the dry floors.

The drying of sewer pipe is almost wholly accomplished on what is known as "sewer pipe floors," by means of steam. These floors vary much in size, according to the output of the factory, and are usually three or four in number, one above another. They are slatted or open, and the steam pipes are arranged beneath the lower one or two. The largest pipes are placed on the lower floor. Exhaust steam from the engine and presses is used by day and direct steam by night. The process is necessarily a slow one, else many of the pipe would crack. Those made from shale are much less apt to crack while drying than those from under-clay.

Sewer pipe are burned, for the most part, in round, down-draft kilns, and the process is essentially the same as that described under paving brick, except that much less time is required, owing to the thin sections of clay to be vitrified. For small pipe three days is usually sufficient, and for the larger four and a half to five. The pipe are usually glazed by the addition of small quantities of packing house salt to the fuel during the last stages of burning. This glazing is done to secure smoothness of surface and a dark color. The color makes little or no difference in the quality of the pipe, but they are largely graded according to it. Prof. Orton has well said: "The system of grading sewer pipe is unnecessarily severe. For any ordinary use the seconds are as good as the firsts. It is not the consumer who profits by the severity of selection; it is the middlemen or retailers, who buy the seconds at low rates and work them off on the public as first-class goods, which, for any matter of service and utility, they are."*

* Ohio Geol. Surv., VII, 214.

The Sewer Pipe Factories of Indiana.—Five factories are at present engaged in making sewer pipe in Indiana. Of these the largest is that of the William E. Dee Clay Manufacturing Co., located at Mecca, Parke County. The clays used at this factory have been described on page 116. Two distinct factories are operated at Mecca by the Dee company. At the older one, erected in 1894, the clay is hauled from the pit in tram cars by horsepower and is dumped by the side of the two dry pans. After grinding it is elevated and descends into three wet pans, where it is tempered for 40 minutes. From these it is passed to the sewer pipe presses, two in number. The size of pipe ranges from three to 24 inches. Three steam-heated floors, 80x208 feet, are used for drying, the length of time varying, according to the size of the pipe, from one to five days. The burning is done in 15 28-foot and six 32-foot round down-draft kilns, the kiln capacity being sufficient to turn two kilns a day, with one kiln laid off for any necessary repairs. From three and a half to four carloads of sewer pipe are gotten from each kiln, the daily output being about seven carloads. From 350 to 400 20-inch pipe can be made on the larger Taplin-Rice press each day. An average of 85 per cent. No. 1, 10 per cent. No. 2 and 5 per cent. culls is gotten from each kiln burned. Salt for glazing the outside of the pipe is secured in carload lots from the National Salt Co., of Michigan.

The larger sewer pipe are made wholly from shale, the smaller from a mixture of one-third under-clay and two-thirds shale. At the old plant flue linings, chimney tops, wall coping, sewer-pipe traps, etc., are molded from under-clay. On account of a strike in the winter and spring of 1904 the output of the old factory for the year was much less than in 1903, when it was valued at \$171,271.

The new factory, about 150 yards south of the old, was erected in 1904, and was not yet in operation at the time of my visit in October, but was fully equipped. It consists of a main building, with three floors, 80x192 feet, for drying; an annex, 60x100 feet, for machinery, and a power house of hollow block, 50x75 feet, for engine and boiler. The waste heat process of drying will be used, the heat entering beneath the lower floor and passing upward. This will be the first time such process of drying sewer pipe has been used in the State.

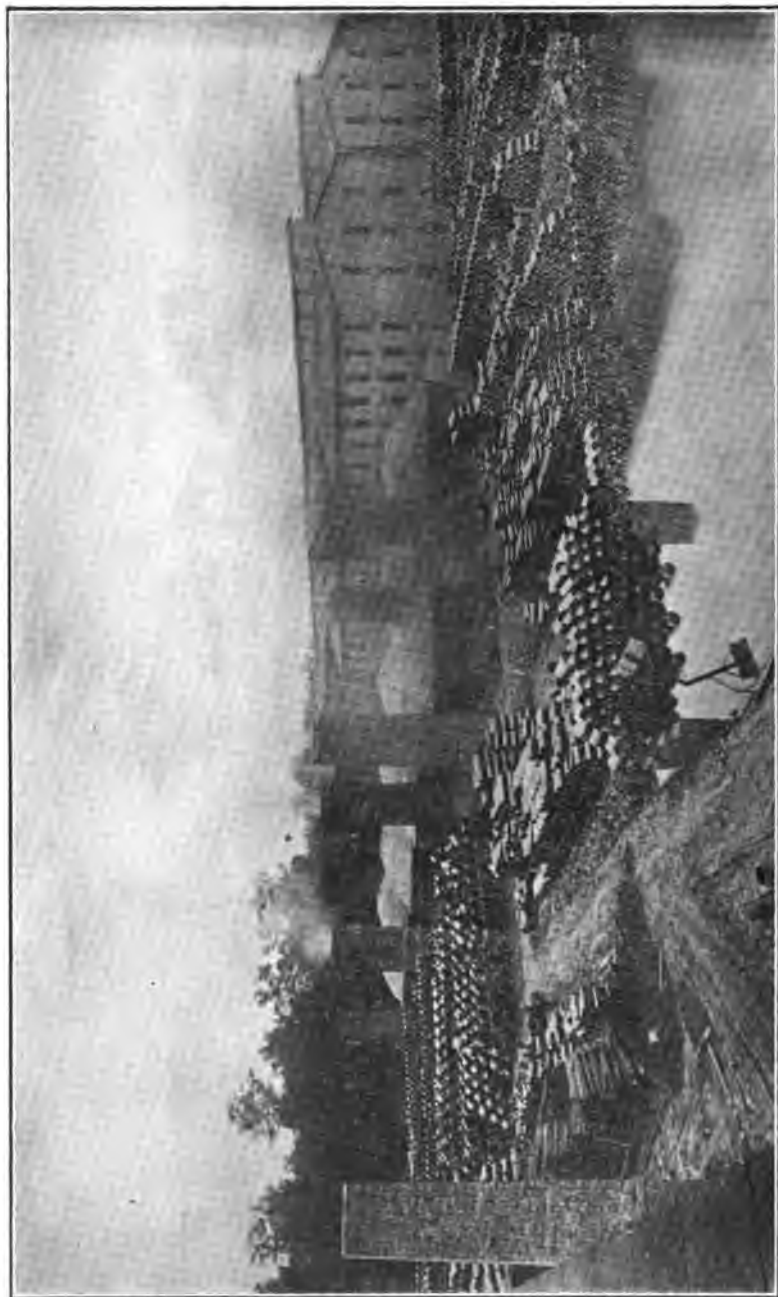
The machinery in place was secured from the Taplin-Rice Co., and consists of two 9-foot dry pans, two 7-foot wet pans and a sewer pipe press, on which three to 24-inch pipe can be made. An auger brick machine will also be installed for making small-sized glazed drain tile and fireproofing. A 350-horsepower Corliss engine and battery of three boilers will furnish the power. Water from Raccoon Creek is pumped to both factories by the C. & E. I. Railway Co. The burning at the new factory will be done in ten 30-foot round down-draft kilns, costing \$2,250 each. These are lined and floored with Evans & Howard (St. Louis) fire brick, the lining costing \$22.50 and the flooring \$44.00 per thousand. Simpson fire brick, from near Carbon, Clay County, are used in the bags of the kilns.

The Dee plants combined form the largest clay industry in Indiana and the largest sewer pipe factory west of Akron, Ohio. The wares are shipped mostly to Chicago and from there distributed to all parts of the middle West.

At the plant of the American Sewer Pipe Co., located one mile northwest of Brazil, Clay County, the clay used is dumped from a tramway leading from the tippie of the mine shaft close by the



Fig. 13. Chimney Tops made from Under-clays by the American Sewer Pipe Company.



Plant and Yard of the Chicago Sewer Pipe Company, Brazil, Clay County.

9-foot dry pans. From the latter it is elevated and passed over a 2x26-foot gravity screen into bins, from which it goes to a pug mill or wet pan. After tempering, it is elevated to the third floor, where it enters one of two Stevenson sewer pipe presses, from two to eight-inch pipe being made on one and 9 to 24-inch on the other. The drying is done on three steam-heated floors, each 80x200 feet in size, and occupies from 36 hours to five days, depending on the weather and the size of the pipe. The dried pipe are trucked to the doors and from there transferred by "gigs" to the kilns. The latter are 14 in number, ranging from 30 to 33 feet in size. The burning occupies three to five days. The plant is operated with a 250-horsepower Corliss engine and battery of three boilers. For further information regarding the clays used and wares produced by this company see page 191.

At the plant of the Chicago Sewer Pipe Co., one mile southwest of Brazil, the clay used (see page 194) is hauled by tram car up an inclined plane and dumped by the side of a 9-foot dry pan. From this it goes through two 7-foot wet pans and is made into pipe on a Barker sewer pipe press. One thousand 18-inch or 1,800 12-inch pipe are made each day. Three dry floors, heated by exhaust steam, each 96x212 feet, are used in drying, the process taking from three to five days, according to size of pipe. Ten 30-foot and two 32-foot standard down-draft kilns are used for burning. From 10 to 11 days are necessary to turn a kiln, i. e., to set, burn, cool and empty.

One kiln of sewer pipe is burned each working day in the year, about 60 tons of clay being used in their making. Twelve different sizes of the pipe are made, ranging from 3 to 24 inches in diameter. The coal used in their burning is Seeleyville bituminous coal. It is not as good as block coal for the purpose, as it contains a higher percentage of sulphur, which is apt to be harmful to the glaze. Twenty-three tons of coal are necessary to burn each kiln of sewer pipe, the burning occupying five days. The factory is run to its full capacity, and almost the entire output is shipped to Chicago, the demand being at all times greater than the supply.

The oldest sewer pipe factory in Indiana is that of Mrs. A. D. Clark, at Cannelton, Perry County. It was established in 1862, but for the past few years has been run only on a small scale (see

page 334). The clay is hauled by wagon and is run through a "chaser," or modified wet pan, without previous grinding. From the chaser it is passed through a press made by Mr. Clark. The pipe made run from 3 to 18 inches in size. The clay is fed into the machine by hand, and but 150 18-inch pipe can be made in a day. Drying is done on two floors, partly by steam. The burning takes four days, two round, down-draft, 20-foot kilns being used. One of these kilns is lined with fire brick made by the Huntingburg Pressed Brick Co. Block coal, from Evaston, costing \$1.87 per ton laid down, is used for fuel. Only eight men are employed, and three to four kilns, valued at \$125.00 each, burned each month. The surface of the sewer pipes made is glazed with salt, and becomes a light reddish brown in color. The pipes are hard, close-grained, very strong, perfect in form, and free from cracks and flaws. They are marketed mostly in Evansville.

The making of hollow building block is rapidly assuming large proportions in western Indiana. Five large factories are now in operation, in which these block form the special output. These block are plain sections of a square hollow bar. Their standard size is $8\frac{1}{4} \times 8\frac{1}{4} \times 16\frac{1}{2}$ inches, with the hollow portion cross-webbed to give them additional strength. One thousand hollow block of the size mentioned are equal to 16,000 common brick in solid wall measure. Many special shapes are also made by the larger factories. They can be made by either the augur or plunger brick machines or in a sewer pipe press, and are dried on dry floors or in progressive tunnel driers.

The advantages claimed for hollow block over ordinary brick or stone for building purposes are as follows:

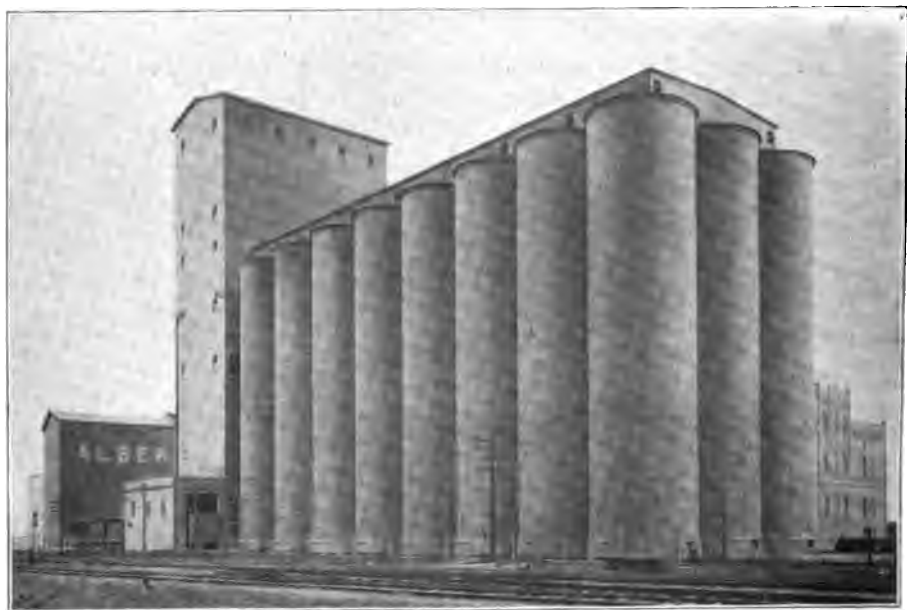


Fig. 14. Hollow Block made from Shale. The Single Block "Rock-faced."

Pl. XXVIII.



Residence constructed of Rock-faced Hollow Block.



Grain Elevator at South Chicago, Ill., constructed of Hollow Building Block made by the Vigo Clay Company. (See p. 581.)

1. Cheapness, costing less than either brick or stone.
2. Being thoroughly vitrified, they do not absorb any moisture and always make a dry wall.
3. Being hollow, they are more healthful for dwelling houses; warm in winter and cool in summer.
4. Make a stronger foundation, as each brick will stand a weight of more than 100,000 pounds.
5. As all ware is vitrified, the walls will always keep clean, and will not become dingy, as cut stone and brick usually do.

A handsome rock-faced tile for foundation work above ground is also made by several of the factories.

Flue linings are made somewhat like sewer pipe, but always out of under-clay. The clay is ground, screened, mixed and then fed into a machine similar to the sewer pipe press. The pieces



Fig. 15. Flue Lining made from Shale or Under-clay.

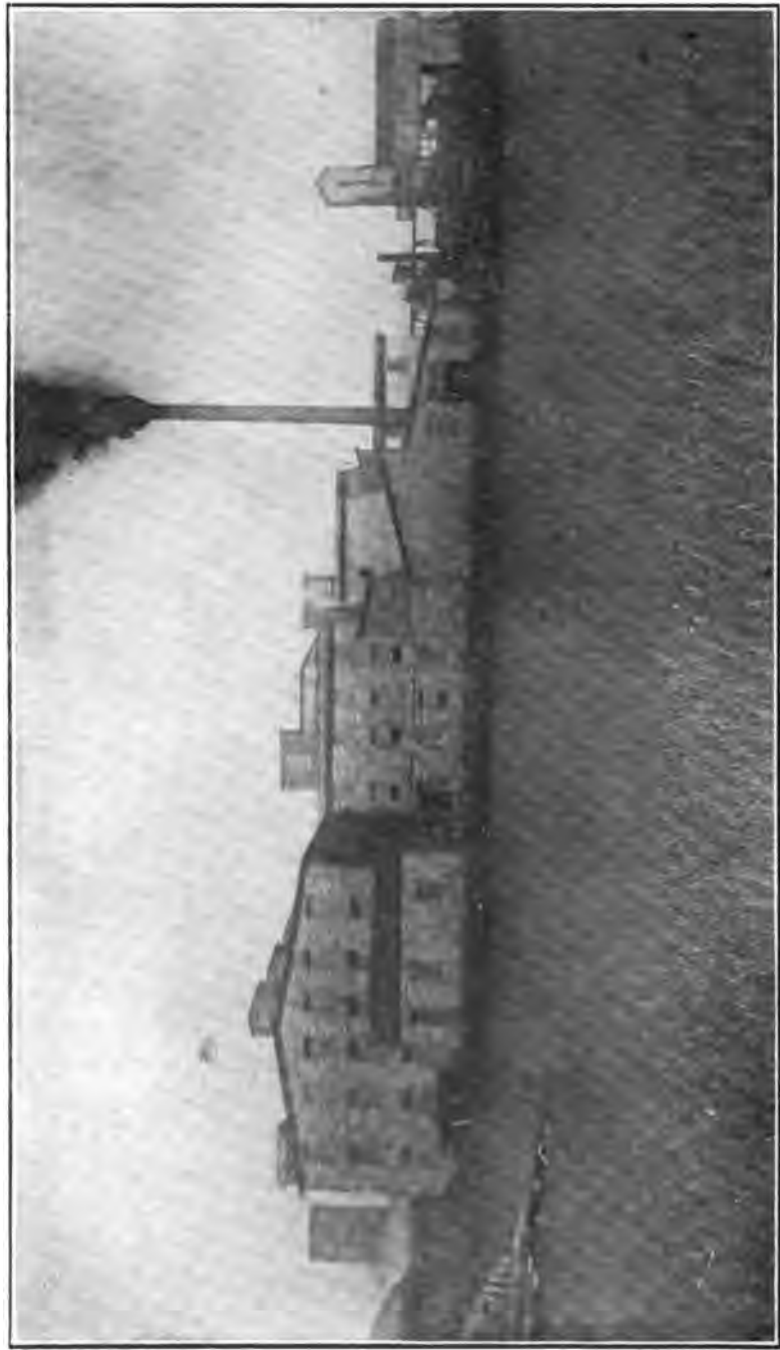
are then dried and burned, but are not salt-glazed like the sewer pipe and are not colored, but have a light buff or cream color. They are made in sections about the same length as sewer pipe, and are of different shapes, but the most common form has a rectangular cross section, with the corners rounded, especially on the inside. These are placed one on top of another the desired height of the flue and a row of bricks built around them. They have the appearance from the outside of a common brick chimney, but give a larger inside space in proportion to the outside than the common flue. It is also smoother, the inside having fewer projections to catch the soot; it is at the same time safer, as there is less possibility of flames or sparks getting through them than through the common brick chimney.

The Hollow Block and Conduit Factories of Indiana.—The largest, newest and most modern Indiana factory for making hollow block and kindred wares is that of the Ayer-McCarel Clay Co., erected in 1902, about a mile and a half north of Brazil, Clay County (see page 188). The under-clay used is hauled up an incline by steam power and dumped in sheds by the side of a crusher, through which it is passed before entering the dry pans. The plant is equipped with American Clay Working Co.'s machinery, as follows: Two 9-foot dry pans, two 10-foot horizontal pug mills, one No. 40 hollow ware auger machine, one No. 2 Giant auger machine.

The drying is done in 24 hours in a progressive eight-track tunnel drier, 110 feet in length, of the company's design, the waste heat process being used. Wares made one day are set the next, the only expense for drying being for the steam necessary to run the 12-foot intake fan, the moisture and cooled air passing out through flues. The average time of burning is 96 hours, this being accomplished in ten 30-foot standard round down-draft kilns. The yard was laid out for 24 kilns, and additional ones will be added from year to year. The power is furnished by an Allfree 250-horsepower engine and two tubular boilers, 72x16 feet in size. A Chandler & Taylor engine is used in running a dynamo to light the factory and office and to pump the water supply from the deep well on the grounds. A repair room, where dies, etc., are kept and repaired, and a handsome office building, equipped with all modern conveniences, are adjuncts of this up-to-date factory.

The principal wares made by the Ayer-McCarel Co. are hollow building block of various sizes and shapes, conduits and radiant chimney block. Since beginning operations, in February, 1903, the demand for these wares has exceeded the output, the shipments being made in all directions within a radius of 500 miles.

At the plant of the Weaver Clay & Coal Co., one mile north-east of the center of Brazil, the clay (see page 184) is delivered by tram cars to the side of the dry pan. From here it passes over an eight-foot shaking screen into a pug mill, where it is tempered with salt water from the deep well on the yard. After tempering it is made up on a Little Giant auger machine and dried by steam on regulation sewer pipe floors for an average of two



Plant of the Continental Clay and Mining Company, two miles southeast of Brazil.

days. The burning is done in eight round down-draft kilns, 26 to 30 feet in size. Power is furnished by a 160-horsepower McEwan engine, while a small engine is used in connection with a dynamo for electric lighting and pumping.

The Weaver Clay & Coal Co. has the reputation of making one of the best rock-face hollow building blocks on the market. They make also drain tile and for more than 30 years have made "stone pumps." The entire pump, except the handle, bolts and suckers, is made of vitrified fire clay. These stone pumps are guaranteed to last for ten years, and a number about Brazil have been in use for 30 years, and are none the worse for wear. They are fitted up and put in the well for \$8.00 for the first ten feet and 25 cents for each additional foot.

At the plant of the Excelsior Clay Works, a mile and three-quarters northeast of Brazil, the clay and shale used (see page 187) is hauled in tram cars up a steep incline and dumped in sheds by the side of a Bonnot 9-foot dry pan. After being ground it passes over a 2x16-foot gravity screen and is tempered in a pug mill. From here it goes, according to the ware desired, either through a Hoosier brick or a Penfield auger machine. If made into vitrified brick the latter are repressed on a Penfield repress. Drying is done by steam in a seven-track, 135-foot progressive tunnel drier, the hollow block being dried in 24 and the paving brick in 48 hours. The wares are burned in nine 26-foot down-draft kilns, the hollow ware requiring four to five days and the paving brick ten to twelve days.

The Excelsior Company makes a variety of products, including vitrified brick and drain tile, hollow block, conduits, flue linings, sidewalk and cellar pavers and common brick. Their wares have a wide distribution, and have given excellent satisfaction wherever tried.

The new plant of the Continental Clay & Mining Co., two and a half miles southeast of Brazil, is equipped throughout with machinery made by the American Clay Working Machinery Co. The building is of three stories, constructed of hollow block. The clay used is dumped from tram cars by the side of a 9-foot dry pan. From this it is elevated and passes over two 18-foot gravity screens into a bin. On leaving the latter it is again elevated to a pug mill on the third floor. From here it descends into a Giant

auger machine, on which 5,000 hollow block, 8x8x16 inches, are made each day. The drying is done in 18 to 24 hours by waste heat, the tunnels from the kilns being so constructed as to allow the heat to pass beneath each of the three floors, 60x40 feet in size. Each floor holds 5,000 standard hollow block. The burning requires 72 to 96 hours, and is done in eight 32-foot round, down-draft kilns, with open bottoms, each kiln holding 5,500 hollow block. These kilns are lined with Montezuma fire brick, and four kilns are connected with one stack, the latter being built of clay conduits. The finished wares on the yard in September, 1904, appeared to be of fine quality, and, with the excellent raw material and fuel at command, there is little doubt but that the new company will meet with unqualified success.

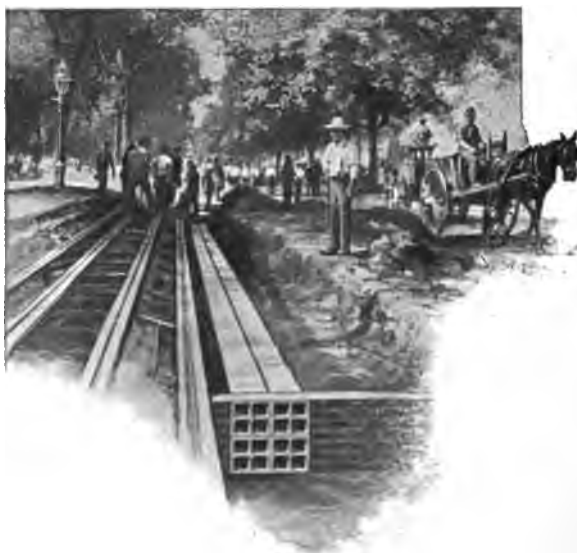
One of the largest hollow ware factories of the State is that of the McRoy Clay Works, located a mile and a half northwest of Brazil. Here the principal wares made are electric conduits and hollow building block. The main building is four stories high and constructed of hollow block. The under-clay used (see page 196) is mined through a shaft, located but a short distance from the main building, and dumped by the side of one eight-foot and two nine-foot dry pans. After elevating and screening, it is tempered in pug mills, four of which are in use, and then made up on two Centennial and two Giant brick machines. The drying is done in 31 steam-heated dry rooms, the main building being chiefly devoted to this purpose. Each room has close-fitting iron doors, and from two to five days are required to dry the wares.

In burning the output of the factory 29 round, down-draft kilns, 26 to 32 feet in size, are used. The conduits are burned 120 and the other wares 96 hours. The plant is operated by electricity, generated by a 450-horsepower Buckeye engine and a battery of five boilers used in connection with a 300-kilowatt general electro generator. Blacksmith and carpenter shops are operated in connection with the plant and a handsomely equipped office forms one of the adjuncts.

The conduits made at the McRoy Works are mostly three feet in length and of four styles, viz., two, three, four and six ducts, each duct being three and a quarter inches square. The four and six-duct styles, which are most extensively used, are also made in six-foot lengths. The material used in their making is the light



Plant of the McRoy Clay Works, one mile north of Brazil.



Illustrating the use of the Conduits made by the McRoy Clay Works,
Brazil, Clay County.

gray siliceous under-clay which was used for a long period in the making of stoneware at Brazil. It burns to a stone gray hue, which becomes a buff when glazed with salt, and the company claim that when burned to the proper point of vitrification it makes a conduit which is a perfect insulator, is impervious to water, and is not affected by heat or cold. It withstands the action of gases, acids and alkalis and is proof against electrolysis, corrosion and decay. The utmost care is exercised in the making of each piece, to guard against cracking, warping, blistering and other structural defects. The wares of the company are used in all the larger cities of the United States, and their superiority is acknowledged by all electrical and mechanical experts.

One of the most successful clay-working industries in Indiana is that of the Vigo Clay Co., about two miles west of the city of Terre Haute.* The clay used is dumped from the tram cars into a pit by the side of a 9-foot dry pan. From the latter it is elevated and passed over gravity screens into a ten-foot pug mill. After tempering, the wares are made on a Giant No. 2 auger machine, the output being 5,000 standard size hollow block each ten-hour day. These are loaded on double-deck iron cars and dried in a Bucyrus progressive 20-tunnel dryer, exhaust steam being used by day and live steam by night. Two days are required for drying and four for burning, the latter being done in 14 round, down-draft kilns, ranging from 22 to 28 feet in size. Wares made from under-clay alone are burned in the smaller kilns, while for all shale ware the larger ones are utilized. It requires about a week to turn the small kilns, while the large ones require 12 days. The plant is operated by a 200-horsepower Crawford-McCrimmon engine and battery of three boilers, and is lighted by electricity generated by a smaller engine and dynamo.

The Vigo Clay Co. started operations in 1901 with but two kilns. By close attention to details and by putting only the best quality of ware on the market, it has built up a trade and reputation second to none. One of the largest contracts which it has received was for 156 cars of hollow block to be used in the structure of the Albert Schwill grain elevator, South Chicago, Ill. This elevator is 150 feet in height and has a capacity of 1,000,000 bushels. It contains 24 grain bins, each 25 feet in diameter and

* For description of clay used see p. 160.

97 feet high. The wares of the company are shipped all over the middle West, and the demand is usually far in excess of the supply. Three tests, made by the Pittsburg Testing Laboratory to show the resistance of the hollow block made by the Vigo Clay Co., resulted as follows, the load being applied on the ends:

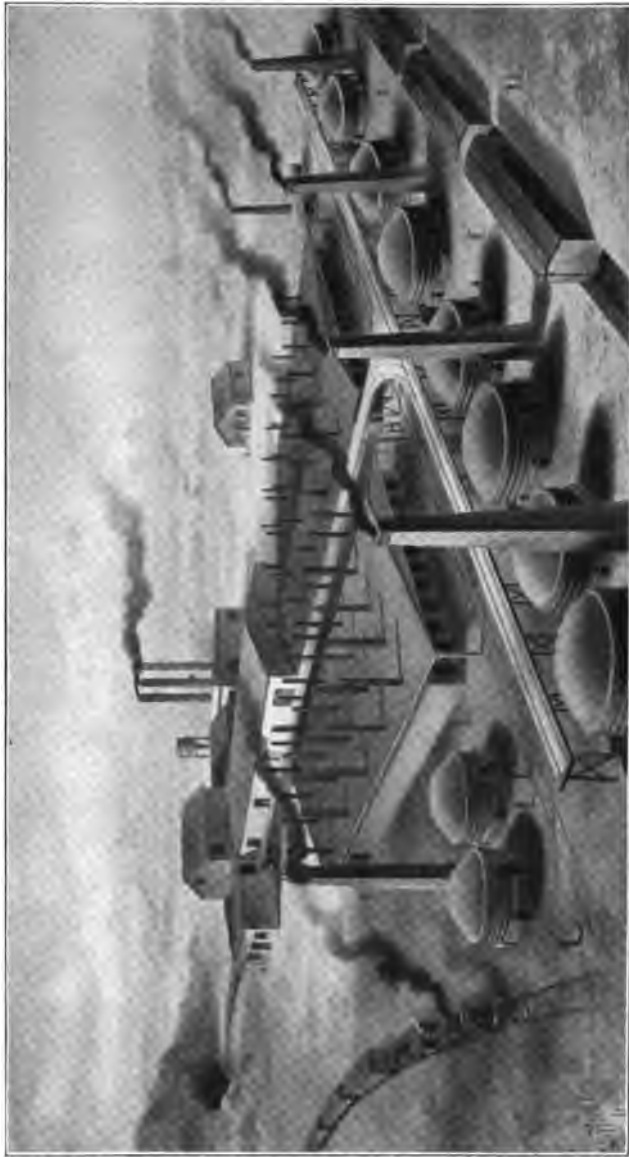
Report of Tests of Hollow Tile Manufactured by the Vigo Clay Co., of Terre Haute, Ind.

Description.	Length.	Area.	Load Applied.	Crushing Strength Per Sq. Inch.
7 $\frac{1}{4}$ inches x 6 inches x 1 inch.....	11 $\frac{1}{2}$ in.	29.25	494,000	16,890
7 $\frac{1}{4}$ inches x 6 inches x 1 inch.....	11 $\frac{1}{2}$ in.	29.25	447,200	15,290
7 $\frac{1}{4}$ inches x 6 inches x 1 inch.....	11 $\frac{1}{2}$ in.	29.25	491,400	16,800

Terra cotta lumber and fireproofing resemble in some respects hollow brick, but they differ in that they are not vitrified, but are made porous and open in texture in order to give them light weight for use in floors and partitions in large buildings. They are hollow and can be bound by rods or bands of steel, or may furnish openings for the passage of gas pipes, electric wires, etc. In their making a silty or marly clay is necessary, the porosity being obtained by mixing three parts clay and one part sawdust, the latter being burned out in burning the lumber, thus leaving cavities in place of the sawdust grains. For this porous wall partition the following points of advantage are claimed:

1. It is a non-conductor of heat, cold and sound.
2. One coat of plaster, without studding or lath, finishes the partition.
3. It can be shaped with edge tools and holds nails and screws.
4. It can be put in place more rapidly and at less cost than brick.
5. Its cost to the consumer is only slightly greater than wood.

On account of its porosity, this "clay lumber" can be readily sawed to any desired shape, and a nail can be driven into it with as much ease as into a pine board. It is used mainly for partition walls in fireproof buildings, and is rapidly taking the place of ordinary brick and solid fireproofing for that purpose. Its advantages over the latter are obvious. On account of a grooved outer surface, plaster is spread over it without the use of intervening lath. Any wood finish can be nailed directly to it; while



Plant of the Vigo Clay Company, two miles west of Terre Haute, Vigo County.

with a saw or trowel it can be quickly cut into any desired shape. Its weight is as follows:

	<i>Pounds.</i>	<i>Sq. Feet.</i>
3 inch.....	13,500	per 1,000
4 inch.....	15,000	per 1,000
6 inch.....	20,000	per 1,000

The prices at which it was sold in 1904 were \$27.50, \$30.00 and \$35.00, respectively, for the sizes made, delivered in Chicago.

But four factories are at present making this porous partition in the states of Indiana and Illinois; one located at Pullman, Illinois, two at Brook, Indiana, and one at Hobart. The demand is constantly increasing, the profits on the ware are very large, and there is no reason why several additional factories should not be at once erected in northern Indiana. Suitable clays occur at a number of places, which have been noted in Section III of the present paper.

The two factories at Brook, Newton County, are, as already noted,* operated under the name of the Brook Terra Cotta Tile and Brick Co., the products made being fireproofing, flue linings, terra cotta lumber, drain tile from four to 24 inches in size, and ordinary brick. At the old or southern factory the mixture of clay and sawdust used in making terra cotta lumber is passed through a pug mill and crushed, and then through an Adrian tile machine fitted with dies of the proper pattern for the product desired. The so-called lumber is in reality a hollow brick, 12x12 inches square and three, four or six inches thick. The walls are three-fourths of an inch thick and the hollow portion has two partitions to give the structure additional strength. The brick are dried in a four-truck standard steam tunnel dryer. After drying they are burned for 36 hours, the sawdust being meanwhile consumed, and leaving the product very light and porous, but at the same time strong enough for all purposes for which it is used. The burning is done in six 22-foot round down-draft kilns.

At the new plant, erected in 1901, two buildings were constructed, viz., (a) the main building or dry shed, 80x160 feet in size, with three floors connected by elevators. The waste heat process of drying is in use, the heat from the freshly burned

* See p. 449.

kilns being forced through tunnels leading from the kilns to the dry floors by a nine-foot fan. (b) The boiler and machinery room, 30x100 feet, the latter equipped with American clay working machinery. The burning at this plant is done in six 30-foot round down-draft kilns.

The output of the two factories in 1904 was valued at \$65,000. The trade of the company is constantly increasing, as they aim to make all of their products of the best possible quality and sell them at reasonable prices.

At the plant of the National Fire Proofing Co., at Hobart, Lake County,* the clay used in the making of terra cotta lumber and other fireproof products, is excavated with spades and elevated in tram cars as fast as needed to the upper floor of the plant, where it is dumped by the side of an opening leading to a perpendicular pug mill. From the opposite side of the building a belt carrier elevates screened sawdust and drops it near the same point. The clay is moistened by sprinkling water over it with a hose, and two men scoop alternate shovelfuls of clay and sawdust into the pug mill. In it the two are thoroughly mixed and then passed into a horizontal brick machine, from which the mixture emerges as a cylindrical roll eight inches in diameter. This is cut into blocks 14 inches long, which are elevated to the top of a Vaughn & Taylor sewerpipe press fitted with dies of the proper size and pattern for the product desired. As fast as taken from the press the wares are placed on double deck iron cars and dried by steam in tunnel driers. The kilns in which it is burned are 14 in number, rectangular down-draft, each one holding 10,000 feet of six-inch partition. The output of the plant averages 30 tons a day of the finished product, and the drying and burning capacity is sufficient to take care of this amount. About nine days are required from the time the clay is taken from the pit until the finished material is ready to load on the cars.

The products of this plant consist of wall partition or fireproofing, from seven-eighths to 12 inches in thickness; floor arching, wall furring, column and girder covering and under-roofing, to which slate or roofing tile can be nailed. Ninety carloads a

* This was the only hollow goods factory of the State which I was not allowed to enter. The description of it is therefore taken mainly from the report for 1897.

month are shipped to all parts of the United States; the value of the annual output being about \$100,000.

The following table comprises the available statistics of the sewer pipe and hollow goods industries of Indiana for the year 1904:

Statistics of Sewer Pipe and Hollow Goods Industries of Indiana for the Year 1904.

NAME OF FIRM.	Location.	Began Operation.	Invested Capital.	Kinds of Products.	System of Drying.	Number and Kind of Kilns.	Kind of Clay Used.	No. of Hands and Daily Wage.	Value of Output in 1904.	No. of Months Worked.
Wm. E. Dee Clay and Manufacturing Co. No. 1.	Mecox, Parke County.	1894	\$120,000	Sewer pipe, flue linings, chimney tops, wall coping, etc.	Sewer pipe floors, steam heated.	21 Round down draft.	Shales and under-clays.	120 \$1.70	\$157,089	10
Wm. E. Dee Clay and Manufacturing Co. No. 2.	Mecox, Parke County.	1904	80,000	Sewer pipe, hollow brick glazed drain tile, etc.	Sewer pipe floors, by waste heat.	10 Round down draft.	Shales and under-clays.	60 \$1.70	Included with above.	2
American Sewer Pipe Co.	Brazil, Clay Co.	1893	100,000	Sewer pipe, culvert pipe, fire-proofing, flue linings, chimney tops, etc.	Sewer pipe floors, steam heated.	14 Round down draft.	Plastic under-clays and shale.	131 \$1.55	125,171	10
Chicago Sewer Pipe Co.	Brazil, Clay Co.	1893	65,000	Sewer pipe, wall coping, etc.	Sewer pipe floors, steam heated.	12 Round down draft.	Shale and surface clay mixed.	75 \$1.69	120,000	11½
Mrs. A. D. Clark	Cannelton, Perry County.	1862	10,000	Sewer pipe.....	Sewer pipe floors, steam heated.	2 Round down draft.	Under-clay and shale mixed.	12 \$1.20	15,000	12
Ayer-McCarel Clay Co.	Brazil, Clay Co.	1903	125,000	Hollow building blocks, conduits, radiant chimney block.	Progressive tunnel, waste heat process.	10 Round down draft.	Plastic under-clays.	65 \$1.85	100,000	12
Weaver Clay and Coal Co.	Brazil, Clay Co.	1872	28,000	Hollow building block, stone pumps, vitrified drain tile, etc.	Sewer pipe floors, steam heated.	8 Round down draft.	Plastic under-clay.	20 \$1.60	32,000	12

Exterior Clay Works.	Brazil, Clay Co.	1885	50,000	Hollow building block, vitrified brick and drain tile, conduits, etc.	Progressive tunnel, steam heated.	9 Round down draft.	Shale and under-clay.	50 \$2 00	24,000	6
Continental Clay and Mining Co.	Brazil, Clay Co.	1904	85,000	Hollow block, cellular pavers, radi-ant chimney blocks and conduits.	Sewer pipe floors, with waste heat.	8 Round down draft.	Plastic under-clay.	30 \$1 86	25,000	4
McRoy Clay Works	Brazil, Clay Co.	1900	100,000	Conduits and hollow building block.	Dry rooms, steam heated.	29 Round down draft.	Plastic under-clay.	140 \$1 65	124,500	12
Vigo Clay Co.	Terre Haute, Vigo County.	1901	50,000	Hollow and special shape building block, fire-proofing, drain tile.	Progressive tunnel, steam heated.	14 Round down draft.	Shales and under-clays.	60 \$1 70	65,000	12
Henry Vance	New Albany, Floyd Co.	1887	5,000	Stone pumps	Dry sheds, by hot air.	1 Round down draft.	Under-clay	4 \$1 50	7,000	8
Brook Terra Cotta Tile and Brick Co. Two factories, a and b.	Brook, Newton County.	(a) 1890 (b) 1901	60,000	Terre cotta lumber, fire-proofing, flue linings, drain tile and ordinary brick.	(a) Standard tunnel dryer, steam heat. (b) Sewer pipe floor, by waste heat.	12 Round down draft.	Silty or marly clays.	60 \$1 80	65,000	10
National Fire-Proofing Co.	Hobart, Lake County.	1887	150,000	Terra cotta lumber and fire-proofing.	Tunnel dryers, steam heated.	14 Rectangular down draft.	Silty or marly clays.	90 \$2 10	100,000	12
Totals			\$1,028,000					917	\$659,760	

III. THE MANUFACTURE OF REFRACTORY PRODUCTS.

The making of refractory wares is carried on in twelve factories in Indiana, but in two of these only as a side issue. Fire brick, cupola linings, tiles for the floors of kilns and grate backs and glasshouse supplies constitute the principal products made.

But three of the factories use Indiana clay, two of them deriving their supply from the stratum below coal VIb in the region between Hillsdale and Newport, Vermillion County. It is a white, semiplastic under-clay of the Coal Measures, contains 98 per cent. of refractory material, and is fully described among the clays of Vermillion County. See page 137.

In the making of fire brick, cupola and furnace block and special shapes of refractory wares, the dry pan is used in grinding the clay and the wet pan or pug mill in tempering it. The latter process is done more thoroughly than in the making of paving brick in order to develop as much as possible the property of plasticity.

The brick and block are molded either by hand or on soft mud machinery, the auger and plunger types of machines being wholly unsuited to their making. Those made on the soft mud machines are much rougher than the ones made by hand, and have to undergo the process of repressing. When first made they are too soft to bear handling and must be partially dried before being repressed. This drying is accomplished on either a dry floor heated by under-flues or in a progressive tunnel. The molding usually takes place in the afternoon and the repressing and setting in the kilns in the forenoon. By this system the bricks are dried in from 12 to 24 hours.

Round down draft kilns are used in the burning of refractory products, the process occupying from five to seven days. Less care is taken in the burning than with any other kind of clay wares, as, on account of the refractory nature of the materials, there is little or no danger of fluxing or overburning.

Within recent years the manufacture of fire brick has been attempted by the dry-press process. The Huntingburg Dry Pressed Brick Company, of Huntingburg, Dubois County, and the Simpson Fire Brick Co., of Carbon, Clay County, are making them by this process in Indiana, while in Ohio it is being

used successfully in several fire brick factories. If the process proves a success it will revolutionize the making of refractory products as they can be made more perfect in form and size, denser and stronger, and at a less cost by the dry press process than by any other known.

Fire Brick Factories in Indiana.—The oldest factory in Indiana making fire brick and furnace block is that of the Burns & Hancock Co., located at West Montezuma, Vermillion County. (See page 138.) The under-clay here used is dumped by the side of two 9-foot dry pans. After passing through these it is elevated and screened; then tempered in a pug mill and made into brick on a Martin soft mud machine. The drying is done with direct heat, in 24 hours, on a dry floor, 70x90 feet in size, which holds 15,000 9-inch brick. Seven round down-draft kilns are used for burning, five days being required. Clinton coal, costing \$1.35 per ton, laid down, is used as fuel.

The fire brick made at this factory weigh six pounds each, and sell at \$12.00 per thousand f. o. b. the cars. All odd shapes made are sold by weight at the same proportionate price, a block weighing 18 pounds bringing \$36.00 per thousand. A large percentage of the output of the factory in 1904 was sold to the Illinois Steel Co., at South Chicago. Large numbers of the brick are sold annually to iron manufacturers as far west as Montana and south to Georgia and Alabama. With the exception of a few weeks in January, 1904, the firm has been behind with its orders for the past six years.

At the new plant of the Southern Fire Brick Co., located between Hillsdale and Newport, Vermillion County (see page 140), the under-clay used is dumped from tram cars by the side of three 9-foot dry pans. After grinding, screening and tempering, it is made up on an American brick machine with automatic cut-off. Drying is done either on a steam heated dry floor, 80x100 feet in size, or by waste heat in a 10-tunnel progressive drier, 24 hours being required by either process. Burning requires seven days, eight 30-foot down-draft kilns being used. The plant is equipped with a 250-horsepower Corliss engine; Murray's smokeless furnace and battery of three boilers; a dynamo for electric lighting; test kilns for testing shrinkage and burning qualities of under-clay and shale; sawmill; blacksmith shop, and

all other accessories of a modern clay working establishment. "Mt. Silica" fire brick and cupola block and tile are the principal wares at present made; and the company is rapidly building up a reputation for the high grade of its products.

At the plant of the Simpson Fire Brick Co., located near Carbon, Clay County, the under-clay used is mined from beneath coal III (See page 181) and dumped by the side of a Ft. Wayne rock crusher and 8-foot dry pan. After being ground and screened it is made into fire brick on a Berg dry pressed brick machine, which has a capacity of 20,000 daily. The burning is done in ten round down-draft kilns and takes from five to seven days.

The fire brick made by the Simpson Company are buff in color, quite tough and solid, and weigh about six and a half pounds each. They are used extensively in glass factories and iron mills and, it is claimed, will readily withstand a temperature of 3,000 degrees F. The output in 1904 was given as 3,000,000, valued at \$30,000. They are shipped mainly to Chicago, and from there distributed to widely distant localities.

Fire brick are also made on a small scale by the Huntingburg Pressed Brick Co., of Huntingburg, and the Uhl Pottery Works, of Evansville, but, as the main business of these companies is the production of other wares, they will only be mentioned in this connection.

The making of glass-pots, linings for glass tanks and other glasshouse supplies forms the highest and most technical part of the refractory clay industry. Seven such factories are in operation in Indiana, but no one of them uses Indiana clays. Glass-pots vary much in size and shape, the larger covered ones weighing as much as 4,500 pounds. Great care must be taken in their structure as in use they are subjected to the most intense heat and at the same time to the action of such powerful fluxes as potash, soda and lead oxides, constituents of the batch of molten material which they contain, and which are much stronger corroding agents than the fluxes of blast furnaces.

The clay used in a glass-pot is subjected to very careful inspection, both at the mine and at the factory. Every lump is broken up by hand into small fragments and every impurity thrown out. This work is frequently done by women. The same care is taken

with the old pots, which are broken to pieces and re-used, every fragment of slag or impurity being carefully chipped off.

As in the lining of a blast furnace, different grades of clay are used in different parts of the pot. Thus the top of the pot has only to withstand the heat and bear its weight while the sides are subject to the weight of the top, the pressure of the liquid and the corroding action of the salt cake.

The clay is prepared much as in fire brick manufacture, except greater care is used in all the processes, and it is put through an extra process called "sweating," in which the moist clay when mixed for use is covered with blankets and allowed to sweat for several months or a year if possible. It is claimed that this has great influence in the working quality of the clay. By some operators the clay is mixed by tramping it with the bare feet, which it is claimed is far superior to any known mechanical process.

The making of the pot is done by hand and is a slow process, taking weeks, and including the drying, even months. It is thus necessary to keep a considerable stock of pots on hand in order to fill orders with any degree of promptness. The pots are not burnt until they are put in the furnace where they are to be used, and then it is the aim to keep them hot until they are burnt out, generally an interval of several months, as they are liable to crack in cooling.

The pots are all numbered and a record kept of them; when they are burnt out they are sent back to the factory and are used as material in building others. As the larger pots weigh from 3,000 to 4,500 pounds each, the material is quite an item and the utilization of the old pots quite a saving. Single pots cost from \$50 to \$60 each.

Up to the present no attempt has been made to utilize the clays of Indiana in the making of glass pots and tank linings. The seven factories making such wares secure their clays mostly from the Christy Fire Clay Co., of St. Louis, and from Mineral City, Ohio, but import some of it from Germany. The average cost of the Missouri and Ohio clays when washed is about \$15.00 per ton. The unwashed Missouri clay, used at some of the factories for furnace blocks, costs \$5.00 per ton. Two clays are found in western and southern Indiana which are undoubtedly of sufficient

purity for glass-pot making. One is the Montezuma under-clay, No. 10, which, according to careful analysis, contains but 1.79 per cent. of fluxes; the other, the Lawrence and Martin county kaolins, containing 1.97 per cent.* The analyses were made from average samples chosen hurriedly, and if careful selection be made, much material of even greater purity will be found in the deposits mentioned.

As Indiana clays are not used, but one of the glass-pot factories in the State was visited. From the blanks sent to the others the statistical information given in the subjoined table was secured.

A plastic refractory clay found in Greene County was formerly put to a novel use by Mr. P. J. Harrah, of Bloomfield. The clay was mixed with one-half of its bulk of sawdust and then molded into an oval mass a little larger than a hen's egg, and with four grooves running lengthwise. During the process of burning the sawdust was destroyed, leaving a porous mass of fire-clay of great refractoriness. A handle of copper wire was attached to this by an ingenious machine, and a fire kindler was complete. This, when dipped into a can of coal oil and allowed to remain over night, absorbed enough oil to burn for 15 or 20 minutes with a flame sufficient to kindle either wood or coal fires. Many hundred thousand of these kindlers have been sold in the past ten years, yielding a handsome profit to the inventor and showing one of the manifold uses to which a refractory clay can be put.

The following table comprises the available statistics of the refractory clay industries of the State for the year 1904:

* For descriptions and analyses see pp. 137 and 390.

Statistics of the Refractory Clay Industries of Indiana for the Year 1904.

NAME OF FIRM.	Location.	Began Operations.	Capital Invested.	Products.	Number of Fire Brick Made in 1904.	Number and Kind of Kilns.	Hands Employed and Daily Wage.	Value of Output in 1904.	No. of Months Worked.
Burns and Hancock Fire Brick Co....	West Montezuma, Vermillion County.	1872	\$50,000	Fire bricks, boiler tile, cupola and furnace blocks, floor brick and ground fire clay.	4,000,000	7 Round down draft.	45 \$1 50	\$45,000	11
Southern Fire Brick & Clay Co.....	West Montezuma, Vermillion County.	1903	130,000	Fire brick, cupola block and tile, ground fire clay.	4,500,000	8 Round down draft.	50 \$1 70	51,000	12
Simpson Fire Brick Co.....	Carbon, Clay County....	1888	60,000	Fire brick.....	3,000,000	10 Round down draft.	30 \$1 70	30,000	8
Huntingburgh Dry Pressed Brick Co.	Huntingburgh, Dubois County.	.....	.....	Fire brick.....	276,000	.....	.....	2,760	.....
Aurora Fire Clay Co.....	Bluffton, Wells County..	1900	13,750	Glass house supplies....	.....	3 Down draft.	15 \$2 05	15,000	12
Gill Bros.....	Muncie, Delaware Co....	1891	12,000	Glass pots and furnace blocks.	.....	2 Small down draft.	30 \$1 75	35,000	12
Diamond Window Glass Co. (Clay Working Department).	Gas City, Delaware Co....	1901	10,000	Glass pots, tank and furnace blocks, floating rings, etc.	.....	.....	15 \$1 75	23,000	12
Brickner Window Glass Co. (Clay Working Department).	Sweetser, Grant County.	1889	8,000	Glass pots.....	.....	.....	6 \$1 75	10,000	12
American Window Glass Co., No. 3. (Clay Working Department).	Hartford City, Blackford County.	1892	10,000	Glass pots, tank and furnace blocks, etc.	.....	8 Burning kilns.	9 \$1 75	30,000	12
Pittsburgh Plate Glass Co. (Clay Working Department).	Kokomo, Howard Co....	1889	.....	Glass pots and furnace blocks.	.....	5 Pot arches.	15 \$2 00	20,000	12
Marion Flint Glass Co. (Clay Working Department).	Marion, Grant County....	.....	8,000	Glass pots and tank blocks.	.....	2 Ovens.	13 \$3 10	10,000	6
Totals.....	.....	.....	\$305,750	.....	11,776,000	.....	223	\$271,760	.....

IV. THE MANUFACTURE OF POTTERY AND ALLIED PRODUCTS.

Clay products made by the potter include both the highest and the lowest types of clay wares. Among them are the rude vessels of uncivilized races and the finest vases and china ware known to mankind. From the one to the other there has been, through many centuries, a steady evolution, with no "missing link" to furnish food for speculation.

Pottery industries are commonly and roughly divided into four classes, which, in ascending order, are as follows:

1. Earthenware.
2. Stoneware.
3. Yellow or Rockingham ware.
4. White ware.

The distinctions are based partly on methods of burning and glazing the ware, and partly on the kind of clay used, and the care and skill taken in preparing it.

1. *Earthenware* is probably the lowest and crudest form of pottery and can be made with proper precautions from almost any clay plastic enough to work freely, and sandy enough to dry and burn without cracking. It differs from common stoneware in being burned at a lower temperature and in being softer and more porous (more earthy). The only forms of earthenware manufactured in Indiana are red flowerpots and jardinières, and they are made only on a small scale in some of the stoneware factories. Drain tile might properly be included in this division, but they are commonly classed with hollow ware or with ordinary brick.

2. *Stonewares* rank next to earthenwares in the scale of pottery products. They are distinguished from the latter by the fact that they are always glazed and usually vitrified, the glazing and burning being accomplished at the same time; whereas in the higher forms of potters' wares two operations are necessary.

The making of the cruder forms of pottery, such as earthenware and stoneware, has long been carried on in the coal bearing counties of Indiana. The early settlers discovered along the sides of the ravines and hills of these counties many outcrops of the under-clays of the coal seams. These, by long exposure, had

been rendered soft, plastic, and in every way suitable for the making of such wares as jugs, crocks, etc. As a consequence, numerous small potteries sprang up, each supplying its own local territory with needed wares. At one time 20 or more of these were in existence, and as late as 1895, eight were listed as then operating in the southwestern portion of the State. Of these, but three remain, the others having been closed by the competition of larger factories. Three of the latter are operating and supply not only a local demand, but ship their wares to distant markets.

Stoneware, to be of good grade, requires much care in the selection of the clay. This must possess certain essential qualities, which may be enumerated as follows:

1. Excessive plasticity, so that it may be easily spun or molded into any desired shape.
2. It must be refractory enough to stand up under the heat required to melt the glaze, and must contain enough free silica to prevent air-cracking while drying, or in cooling after burning.
3. It must possess fluxes sufficient to cause vitrification to partially take place at or below the temperature required for glazing and so be rendered impervious to water.
4. It must be relatively free from such impurities as particles of lime, iron sulphide, etc., which will cause a flaking or blistering of the surface after burning.
5. It should burn with a clear and uniform tint.

Numerous clays possessing these qualities exist in southwestern Indiana. Among the best are those found in the vicinity of Annapolis, Parke County; Brazil and Clay City, Clay County; Shoals, Martin County; Huntingburg, Dubois County, and Cannelton, Perry County, detailed mention of each of which is given in the previous section.

In the smaller factories the clays are usually weathered for some months before using. They are then ground for some time with the old-fashioned horse-power "grading" machine. This grinding causes the clay to become very tough and waxy, but does little toward removing the impurities.

In the larger factories the clay is either ground or washed. A machine run by steam and called a tracer, or "chasing mill," is used for grinding. By this the clay, previously moistened, is ground, kneaded and stirred for an hour or longer until the

grains have been reduced to as near a uniform size as possible, and the property of plasticity strongly developed. The clay thus ground is used mostly for hand turning, while that used for molding or "jollyng" is generally washed.

After being ground and tempered by one of these two methods, the clay is then removed to the turning room, where a piece is cut off of sufficient size and weight to make the vessel desired. This is cut into two pieces several times by a wire, and each time reunited by throwing one mass with much force against the other. By this means, and by kneading, the air bubbles are worked out and the particles of clay brought into closer contact. The clay is then thrown on to a horizontal disk, or wheel, which can be made to revolve rapidly by a foot lathe or other power. By moistening the revolving mass and pressing it with the fingers the experienced potter can cause it to take any desired shape.

The amount of ware thus turned in a day varies much according to the size and kind. So many gallons usually constitute a day's work. A practiced potter can make as many as 125 to 150 gallons of crocks or jars; while 70 to 90 gallons of jugs will be a good day's labor.

In the larger factories at Brazil and Evansville, much of the ware is formed by jollyng or molding. For this purpose, the clay is first washed, or beaten into a thin slip or fluid pulp with water, and then, after sifting out all coarse particles, the watery and soluble impurities of the clay are removed by filtration.

The washing is begun in a "blunger" or large vat, either of wood or iron. Into this the raw clay is shoveled and stirred with water by a set of revolving paddles until it is reduced to a thin slip or fluid pulp. From the blunger this pulp is passed over a 60-mesh brass wire-cloth screen where any pebbles and coarse material are separated. The fine clay and liquid are then run into an agitator from which it is pumped into the filter press. This "press or filter is the most ingenious and most troublesome part of the washing machinery. It consists of a series of iron or wooden frames suspended on iron side bars. These frames are covered with single or double layers of stout canvas or duck, made for the purpose. Through the center of each frame is a hole; also lined with duck. When a press is in order, ready to

fill, these frames or chambers are squeezed up tight against each other by a powerful screw at one end of the press. The canvas between the edges of the iron frames makes a tight gasket or joint and the holes in the center coincide all the way through, so that between the canvas of each two frames, there exists a duck-lined cavity, communicating by the central hole with the similar chambers on either side of it. When the slip is pumped in, it fills these cavities and the water soaks out through the canvas and drains away, leaving the clay behind. When the cavities are filled and no more slip can be pumped in at a pressure of 125 pounds to the inch, the operation is complete. The screw is loosened, the frame separated and the clay is disengaged in flat leaves or plates, one to two inches thick and weighing 36 to 40 pounds each in the ordinary sizes.”*

In the process of jollying or molding, a rapidly revolving mold made of plaster of Paris is filled with the soft washed clay. The inside of the mold has the form of the outside of the desired piece of ware, while a “shoe” or “pull-down” is used to regulate the inside shape. When the operation is complete the mold is taken into a hot closet where the water of the clay evaporates, and the ware shrinks and loosens in its case. The handles are put on after the ware is removed from the mold. By this process a single mold can if desired, be used two or three times a day, and many more pieces of ware can be made by one man than by the old-fashioned mode of turning.

The ware, after being shaped on the wheel or by jollying, is set on board shelves in open racks, or in large airy rooms where it slowly dries. After drying, if the glazing is to be that of a slip clay, it is dipped into a solution of such clay and then, after allowing this to dry, is removed to the kiln. There, at the proper temperature, the slip melts and forms a smooth and handsome surface, usually of a dark brown color. At some factories an artificial slip glaze is used which burns white.

If the glaze is to be one of common salt, the ware is removed directly from the drying room to the kiln without being dipped in a glaze bath, and when the contents of the kiln are at a white heat the salt is thrown on the fire. Its vapors pass upward and form a brownish yellow glaze on the outside of the ware. The

*Orton. Geol. Surv. of Ohio, VII, 1893, 99.

most common practice is to use a slip clay on the interior and a salt glaze on the outside, although in some grades of ware slips are used for the outside as well as the inside. The slip is mixed thin and sprayed over the interior of the ware, which is then ready for the kiln.

The best known natural slip clay in this country is the Albany slip, from Albany, New York, which is the one used almost exclusively among the potteries of Indiana. Slip clays which have been tried with satisfactory results occur in this State in Parke and Elkhart counties (See page 109). The question of slips and glazes is intimately associated with other classes of pottery, and enameled brick and glazed tiling. It probably calls for more technical skill than any other phase of the industries, especially in the ornamental ware.

Most of the stoneware made in Indiana is burned in 22-foot round down-draft kilns, the process occupying about 60 hours. Each kiln holds from six to eight thousand gallons. Three days must elapse after the fires are drawn before the kiln be opened, else much ware will be spoiled by air cracking.

The Stoneware Factories of Indiana.—The largest stoneware factory in the State is that of the Standard Pottery Co., located one mile southwest of Brazil (See page 195). In this factory both turning and jollying is done, four turners and five jollymen, with their helpers, being steadily employed. All wares from six gallons in size up, are hand turned, the clay being ground and tempered in a chaser. Each turner receives from 87½ cents to \$1.25 per 100 gallons, depending on the size of the ware. After paying his helper, he makes an average of \$4.25 per day.

In jollying the smaller sized wares, only washed clay is used. This, after passing through a double blunger mill, screens and agitator, is pressed on two 72-chamber filter presses, and then thoroughly tempered in a pug mill. The wares made are mainly jugs, jars, crocks, churns, fruit jars and water coolers, from one-half gallon to 30 gallons in size. The smaller sized ware is dried 24 hours in the molds and another 24 hours after being removed. It is then taken to the slip room and from there is carried to the kilns. This ware is easily glazed with Albany slip clay, which is used mainly for glazing the inside of the larger pieces, while

a white glaze, made of feldspar, flint, Paris whiting, ground glass, oxide of zinc and white lead, is used for the outside. The burning is done in four 22-foot round down draft kilns.

The ware made by the Standard Pottery Co. is of high grade and brings an average of four and a half cents a gallon, the larger pieces selling for five and a half cents. It is shipped to various points within a radius of 200 miles from Brazil.

The Uhl Pottery Works, of Evansville, operate a large plant in the northern part of that city, and have been making stoneware since 1891. They use, for the most part, the Huntingburg potters' clay, though they burn some wares from the Cannelton clay. The Huntingburg clay will, it is claimed by O. C. Lee, the superintendent, stand fire better for light glazing. The clay costs about \$2.00 laid down at the pottery. About 125 30-ton cars are used each year.

All the clay used for molding stoneware is reduced to a fluid pulp in two cylindrical agitators, each five feet in height by four in diameter. From there it goes to a receiving cistern, from which it is pumped into a clay press. Here it remains about an hour; seven pressfuls a day being used, each averaging 2,700 pounds of washed clay. This is tempered in a pug mill and then goes to the jollymen.

The clay used by the turners is not washed, but is run through a chaser. Five jollymen and two turners are employed. The ware is dried for 40 hours, and then glazed with a white bristol glaze. The burning is done in two 22-foot and one 16-foot round down draft kilns. The output in 1904 was 600,000 gallons, which was mostly sold in Tennessee, Alabama, Georgia and other Southern States, and brought an average of five cents per gallon f. o. b. the cars.

Besides stoneware, the firm make about 100,000 fire brick each year from a mixture of the Huntingburg clay and broken saggars. The latter are secured from the Crown Potteries Co., 300 feet south, and cost 75 cents a ton. Three parts of the saggars are ground with one part of the Huntingburg clay, to serve as a bond. The brick are made on a stiff mud machine and then repressed. They bring about \$18.00 per thousand.

At the stoneware factory of Clark, Rose & Co., at Cannelton, the clay is not washed before using, being simply ground and

tempered by steam power in a wet pan or "chaser." Three turners and one jollyman, with their helpers, are employed. The drying is done in steam heated closets for 24 hours. The burning takes 60 hours and is accomplished in one 18-foot round down draft kiln, holding 4,000 gallons. An average of one kiln a week is made and burned. The ware consists mainly of crocks, flower-pots, pitchers, jugs, jars and cuspidors, the largest sizes being ten gallon jugs and 12 gallon jars. Albany slip clay, costing \$134 for a 20-ton car at the plant, is used for glazing. The ware made is sold wholesale for four cents, and retails for seven cents per gallon. It is marketed mostly at points along the Southern Railway, and gives everywhere the best of satisfaction.

At the pottery of V. Walz, in Huntingburg, Dubois County, the clay is pugged and tempered on an old-fashioned grading machine by horse-power, and most of the ware is turned, molds being used only for crocks. A new Henry Martin combined wet and dry pan or tracer is on the ground and will soon be installed. The ware is dried by air in racks on the two floors of the factory, the length of time required depending on the weather. Burning is done in one 14-foot round down-draft kiln holding about 2,500 gallons. A kiln is burned every three weeks for 11 months of the year. Stoneware of various kinds, "stone pumps" and four sizes of gutter piping for cisterns, etc., are the principal products made. The largest sizes of pottery made are 20-gallon jars and 10-gallon jugs. Albany slip clay, costing \$2.00 per barrel, is used for glazing. The ware brings four and a half to five cents per gallon wholesale, and retails at an average of eight cents. It has a good reputation throughout southern Indiana, where it is mostly sold.

At Loogootee, Martin County, John H. Folks has operated a small pottery since 1878. The clay is ground and tempered on a grading machine and all ware is turned. Burning is done in a small stone Howard up-and-down-draft kiln, lined with fire brick. This holds 2,200 gallons and only five or six kilns are burned a year. Natural gas is now used as fuel and the burning takes 60 hours. When wood was used but 36 hours were required. Albany slip is used for glazing. Both stoneware and earthenware are made, the former being mostly jars, jugs and crocks, and the

latter flowerpots and jardinieres. The ware sells from five to eight cents per gallon and is sold only to the local trade.

The pottery of Beryl Griffith, located at Clay City, Clay County, was established in 1846. The clay used (See page 206) is ground and tempered on an old-fashioned grading machine. The larger sized jars, jugs and churns are turned, while all smaller sizes are made in molds. Drying is done by steam in 24 hours. Albany slip clay, costing \$1.50 to \$2.00 per barrel, is used. The wares are burned in a round down-draft kiln holding 3,000 gallons.

Besides the stoneware mentioned, earthen flowerpots and jardinieres are also made on a small scale. The wares made are of high grade and are mostly sold in Clay City and at points north and south on the E. & I. Railway.

The oldest pottery in Indiana is that of H. R. Atcheson, located at Annapolis, Parke County, which was established in 1841. In it the potters' clay, No. 8 of the Coke Oven Hollow section (See page 102), is used, being hauled in wagons to the pottery. Here it is ground by steam power on a chaser mill, and then turned or molded into jugs, jars, crocks, churns, and other forms of stoneware. These are dried by steam and burned in a round down-draft kiln holding 4,000 gallons. The ware is strong and durable and has a wide reputation throughout central Indiana for the excellence of its quality. It is wholesaled at the factory for four cents per gallon.

3. *Yellow or Rockingham Ware* is not at present made in Indiana, though formerly manufactured at Troy, in Perry County, in large quantities. A natural clay is used in its making. This, after being molded and dried, is first burned in the biscuit kiln to harden the body and then burned again to develop the glaze. The same clay may be used for both stoneware and yellow ware, but a less refractory clay may be used for the yellow or Rockingham ware, because the glazes fuse at a lower temperature than the stoneware glazes.

4. *White Wares*, including C. C. ware, white granite, semi-porcelain, and porcelain, stand at the head of the list of pottery wares, both in the purity of the clays and other materials entering into their composition, and also in the skill required of the operator for their successful making and burning.

The white ware industry differs from that of the other grades of pottery ware mainly in the complexity of the mix or material used. Instead of using a natural clay alone, mixtures of clay, kaolin, feldspar and quartz are used, the clay in some cases forming a comparatively small percentage of the total. In the five factories making white wares in Indiana no clay from the State is used except for the making of saggars. These are boxes or cases of various shapes and sizes, made of refractory open grained clay which will stand a high heat and much handling. In these saggars the smaller and more delicate pieces of unburned clay wares are packed and separated by small pieces or "wads" of clay, so that the weight of one piece upon another will not deface or bend it. These saggars of unburned ware are then set in the kiln, one on top of another, until it is filled, when the process of burning begins. The expense of the labor and material in making the necessary saggars in a large factory is quite an important item. Two or three men are generally kept busy at that alone.

The technique of the white ware industry is too varied and too complicated to justify more than a brief description in this connection. Since Indiana clays are not used in the formation of the body of the wares, but one of the five factories operating in the State was visited personally. This was that of the Crown Potteries Co., of Evansville, makers of semi-porcelain and white granite tablewares. A short description of the process therein used will give some idea of the making of white wares.

The Crown Potteries Co. was organized in 1891, and now operates large factories at Evansville, Ind., and Peoria, Ill. At Evansville the materials used in the body of their wares consist of ball clay from Tennessee, kaolin from North Carolina and Georgia, feldspar from Pennsylvania, ground flint from East St. Louis, Ill.; also an imported kaolin. Huntingburg (Ind.) clay is used for saggars, about 250 tons a year, costing \$1.50 at the plant, being required. The saggars are molded by hand, are of different sizes and shapes and are dried in a steam-heated dry closet for about a day. They are then filled with light ware and used the first time without burning, the new ones being placed on top of the older ones in the kiln. Each saggar can be used on an average only about five times. It is then ground up and its material, mixed with fresh clay, is used in forming another one of its kind.

In making the body of the porcelain and other wares, the materials used are thoroughly mixed in the proper proportion. The mixture is then put through a clay press, similar to that used in making stoneware. All the wares are molded, dried in steam-heated closets, then smoothed, piece by piece, placed in saggars with small "wads" between each two pieces, and burned in kilns of special design for 60 hours, the temperature being kept at about 2,000° F. After cooling, the ware is then carefully gone over and all defective pieces rejected. The perfect ones are then dipped in an artificial glaze, whose main ingredients are zinc oxide, white lead, boracic acid and Paris whiting. They are then placed in a second set of saggars in such a manner that no two pieces touch, and burned a second time for 28 hours. After cooling, the ware is again assorted and all roughness removed. The plain ware is then ready for the market, but that which is decorated, which comprises the greater part, is taken to the decorating rooms. Here the colors used are enamel paints, or readily fusible glazes, colored with metallic oxides and used as paints. The decorating is done chiefly by "transfer papers" or "prints," though some of the finer ware is hand-painted. After decorating, it is again placed in saggars and burned a third time, eight to 12 hours, in special decorating kilns, six of which are in use; the object of this burning being to "fix" or render permanent the decorations.

The wares made by the Crown Potteries Co. rank high, both in quality and in the artistic beauty of their decorations. Their trade has grown very rapidly, and at present their output ranks first in value among the clay industries of the State.

The Peru Electric Manufacturing Co., located at Peru, Miami County, manufactures a standard line of porcelain electrical appliances. Among these are electric sockets, receptacles, cut-outs, attachment plugs, circuit boards, bases for baby switches, fuse and fuseless rosettes, insulators, cleats and many other specialties. All the clays used are brought in from other States, being for the most part ball clay from Florida and the so-called "china clays." The wares are all dry-pressed in steel dies. They contain about 3 per cent. moisture, which is removed by air drying. They are then placed in saggars and burned for 24 hours. Ten modified patent down-draft potters' kilns are used. Natural gas

served as fuel until 1901, but has been replaced by West Virginia gas coal. The output of the factory goes to all parts of the United States, and has a high reputation for nicety of finish and durability.

Three companies in the State are engaged in the making of sanitary earthenware, such as bath and laundry tubs, sinks, lavatories, etc. The ware is made and partially dried in plaster of Paris molds, then air-dried and burned in saggars in kilns. Great care is necessary in drying the large pieces and still greater care and skill are required in the burning and cooling or annealing operations.

The objections to bathtubs of porcelain are their greater weight, which is from 500 to 700 pounds, and greater cost. These objections apply in a less degree to the sinks and laundry tubs. Yet they are so much neater and cleaner that for the better class of buildings they will be in demand in spite of their greater cost. The greater weight is not a serious objection, as they are stationary objects.

At the plant of the Great Western Pottery Co., located at Kokomo, Howard County, no Indiana clay is used, either in the body of the ware or in making saggars. Some clay from the State was tried for the latter purpose, but was not found entirely satisfactory. The body clay is obtained in England and various parts of the United States. Five biscuit and three gloss kilns are used in burning.

At the plant of the Columbia Pottery & Manufacturing Co., also located at Kokomo, the clays for the body of the wares are obtained from England, Kentucky and Florida. Five kilns are used in burning.

The National Pottery Co., of Evansville, uses clays from England, Florida and Delaware. Four straight up-draft kilns are in use.

The wares of all three of these companies rank among the best of their kind in the United States, and have a wide distribution, especially in the larger cities of the country.

The following table shows the more important statistics of the pottery and allied industries of the State for the year:

NAME OF FIRM OR INDIVIDUAL.	Location.	Began Operation.	Capital Invested.	Products.	Number of Kilns.	Kiln Capacity in Gallons.	Output in Gallons in 1904.	Value of Output in 1904.	No. of Hands Employed.	No. of Months Worked.
Standard Pottery Co.....	Brasil, Clay County	1885	\$44,000	Stoneware	4	40,000	1,200,000	\$42,000	47	11
Uhl Pottery Works.....	Evansville, Vanderburgh Co	1881	19,000	Stoneware, fire brick, and linings and clay specialties.	3	18,000	600,000	30,000	30	12
Clark, Rose & Co.....	Cannelton, Perry County.....	1882	2,500	Stoneware and earthenware.	1	4,000	200,000	9,000	8	12
V. Wals.....	Huntingburgh, Dubois Co....	1880	3,000	Stoneware, earthenware, stone pumps and gutter piping.	1	2,500	33,000	1,750	4	11
Jno. H. Folks.....	Loogootee, Martin County ..	1877	2,000	Stoneware and earthenware.	1	2,200	13,200	750	2	6
Beryl Griffiths	Clay City, Clay County	1846	2,000	Stoneware and earthenware.	1	3,000	16,000	800	3	9
H. R. Atchison	Annapolis, Parke County ..	1841	3,500	Stoneware	1	4,000	112,000	4,480	10	7
Crown Potteries Co.....	Evansville, Vanderburgh Co ..	1891	200,000	Semi-porcelain and white granite tableware.	9 General burning. 6 Decorating.			220,000	300	12
Peru Electrical Manufacturing Co.	Peru, Miami County	1889	150,000	Porcelain electrical appliances.	10 Down-draft.			100,000	110	12
The National Pottery Co.....	Evansville, Vanderburgh Co ..	1903	85,000	Sanitary earthenware.....	4 Straight-up draft.			75,000	65	10
The Great Western Pottery Co.	Kokomo, Howard County	1893	200,000	Sanitary earthenware.....	5 General burning. 3 Gloss.			200,000	125	12
Columbia Pottery and Manufacturing Co.	Kokomo, Howard County	1903	100,000	Sanitary earthenware.....	5 Up-draft.			150,000	80	12
Total.....			\$811,000				2,174,200	\$833,780	784	

V. THE MANUFACTURE OF DRY PRESSED BRICK, ARCHITECTURAL TERRA COTTA AND ENCAUSTIC TILE.

The three classes of products above mentioned comprise the highest grade clay materials used in the construction of buildings. The chief principle involved in the making of dry pressed brick and encaustic tile is the same, viz., the use of great pressure to cause the particles of clay to adhere into a dense and compact product. In the making of terra cotta the larger pieces are usually made in molds of special design.

The manufacture of dry-pressed brick for the fronts of buildings has become a prominent industry in recent years. Architects and builders are constantly inventing new designs in which these bricks can be used to advantage; and the manufacturers, fully alive to every opportunity for increasing their business, are competing with one another in improving the quality and variety of their output.

Clays of various kinds are used in the making of dry-pressed brick. Surface clays, where free from particles of lime and iron ore, make a handsome red brick, but oftentimes one which is too tender or brittle, the edges being easily broken or rubbed in shipping. Such clays are used in two of the five large factories operating in Indiana. Recent sedimentary clays make a tougher brick, but the color cannot always be relied upon.

The toughest pressed brick, and those of the most uniform color, are undoubtedly those made of shale. The Knobstone shales and the more refractory deposits of the Carboniferous can be made into a handsome and durable dark red brick. The under-clays of the coal seams can also be utilized in making buff brick, which are rapidly coming into popular favor. By mixing these clays and the overlying shales or surface clays in varying proportions, many different shades can be produced at will.

In general, the only preparation necessary for the clays is grinding and screening. The surface and sedimentary clays are usually ground in a pulverizer, the shales and under-clays in a dry pan. The grinding should be prolonged enough to render the particles of clay as near a uniform size as possible. From the screens the clay passes down to a receiver or hopper above the

brick press. The latter is a powerful machine, which takes the ground and screened clay, and by the exertion of great pressure forms it into a dense, compact brick. As this is usually made without the aid of moisture, it is but little more than an aggregation of particles of clay, held together by the force of adhesion. Such brick are, therefore, acted upon and worn away readily by friction, and require careful handling, both before and after burning.

The brick are usually removed from the machine direct to the kiln. The burning is accomplished in down-draft kilns, either round or rectangular in form, the Eudaly being a favorite kiln for the purpose. The process occupies from eight to fourteen days, about half of which are devoted to water smoking. Wood or coke is generally used for fuel in this preliminary process and coal for the later stages of burning. In two of the factories continuous burning kilns are used, and waste heat is utilized for drying thoroughly before burning, the latter process being thereby much shortened.

After cooling, the contents of the kiln require careful assorting, as sometimes as many as a half dozen different shades of one color are present, owing to the variations in burning, and the position occupied by the different courses of brick in the kiln.

Dry Pressed Brick Factories of Indiana.—One of the most modern factories for making dry-pressed brick in Indiana is that of the Kulage Brick Works, at Hobart, Lake County. The clays here used (see page 456) are put through a double process in order to render the completed wares stronger, more durable and more uniform in texture. The clays are first made into large-sized, stiff mud brick on a Chambers machine, 50,000 such brick being made each day. These are dried for 48 hours in a steam-heated 10-tunnel dryer. They are then crushed and ground into dust, which is elevated in a conveyor and falls into a mixing room. From this it is removed by an auger conveyor to an elevator, which conveys it to the dry-pressed brick machines. Four of these are in use, two "Triumph," for plain brick, and two "Challenge," for ornamental and odd shapes. From the machines the brick are taken to the kilns, where they are subjected to a drying process by waste heat for seven days, and then are burned the same length of time.

Coal from Linton, Greene County, is used as fuel, and costs \$2.00 per ton at the factory. Two hundred tons are required to burn 300,000 brick.

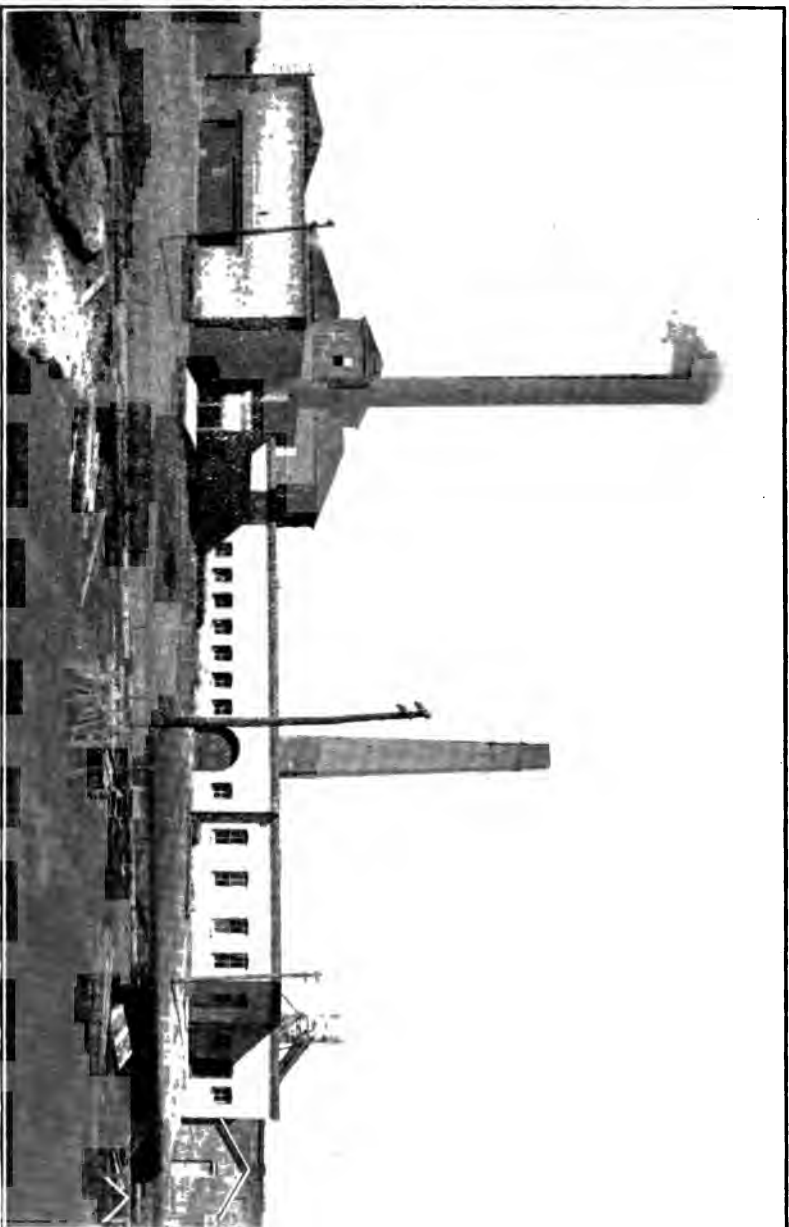
Five large rectangular down-draft kilns, each 100 feet long by 20 wide, and holding 300,000 brick, are in use. These kilns are constructed of ordinary brick, burned from the clays at hand, and are lined with Ottawa fire block. They were built according to the designs and inventions of the Kulage Company, and are the largest kilns of the down-draft type in the State, their combined capacity being nearly as great as that of a dozen down-draft kilns of the usual size. Each kiln is so constructed as to be operated separately and independently, or the entire set may be connected and used as a continuous system, thereby reducing materially the cost of burning. At the present time the kilns are operated continuously, the processes of setting, drying, burning, cooling and unloading taking place all the time, one kiln being in use for each process. These kilns also admit the setting and burning of shaped, ornamental, glazed and enameled brick with the plain brick without interfering with the latter.

In removing and assorting the brick from the kilns, they are taken out in sections, those from four double rows being practically uniform in color. Five different colors are obtained from each kiln. Those of an ordinary pink hue sell for \$10.00, while the maroon bring \$13.00 per thousand f. o. b. at the factory. The ornamental and special shapes range in price from \$50 to \$200 per thousand.

In order to show the difference in strength between brick made by the old dry press process and those by the new, or one now in vogue at the factory, Mr. Kulage had tests made by Robert W. Hunt & Co., of Chicago, which resulted as follows:

Results of Crushing Tests on Half Brick from the Kulage Brick Works, Hobart, Ind.

	<i>Old Process Brick.</i>	<i>New Process Brick.</i>
Dimensions	3.79x3.85 in.	3.82x4.00 in.
Area square inches	14.59	15.28
Load at cracking, actual.....	148,000 lbs.	198,000 lbs.
Maximum load, actual.....	200,000 lbs.	.....
Load at cracking, per sq. in.....	10,145 lbs.	12,960 lbs.
Maximum load, per sq. in.....	13,710 lbs.	.....



Plant of the Kulage Dry Pressed Brick Works near Hobart, Lake County.

"The new process brick was loaded to the capacity of machine, 200,000 pounds, but was not destroyed."

The brick from the Kulage factory have a wide distribution, being, in 1904, sold in Philadelphia, Milwaukee, St. Paul, St. Louis and many other cities. With the process in use, it is claimed that they are made more cheaply, and will withstand rougher handling than when made by the old method. Consumers prefer the brick on account of their greater toughness, and there is also a minimum of loss in shipment.

The largest dry-pressed brick factory in Indiana is that of the Chicago Hydraulic Pressed Brick Co., located at Porter, Porter County. Here the clay used (see page 460) is hauled in trucks and so dumped as to feed itself between a set of steel rollers. These grind enough clay to make 25,000 brick every ten hours. After being ground, the clay is elevated to the top of the building and passed through a disintegrator and two rotary or revolving screens. From the latter it descends into a perpendicular "mixing box," eight feet in diameter, where it is acted upon by revolving iron arms, and reduced to as nearly a homogeneous mass as possible. From the mixer it passes into a five-die hydraulic press, the company's patent and make. This subjects it to a pressure of 2,750 pounds per square inch. Three such presses, each capable of making 25,000 brick daily, are in the plant, and connected with each of these is a set of steel rollers, disintegrators, screens, etc., as noted above. Besides these there is a press for making brick of special shape, which has but two dies and makes 2,500 brick daily.

From the presses the brick are wheeled on trucks to the kilns. These are of the "Groves" pattern, and 14 in number, each holding 130,000 standard-sized brick. The kilns are so connected with one another and with a system of large exhausters or "blowers" that as soon as one is filled and hermetically sealed the cold air which it contains is drawn off, and hot air from a freshly burning kiln rushes in to take its place. In this way much heat is saved for drying which would otherwise be lost. After drying for a week the brick are burned, with coal as fuel, for an equal length of time. Illinois screened lump is used, costing \$2.20 per ton delivered. Seventy tons are used in burning each kiln.

From the kilns the brick are taken to the stock room, 710 feet long, 33 feet wide and 14 feet high, where several millions of front brick of many colors, as well as large supplies of special shape brick are kept constantly on hand. A double railway track runs through this room, so that the brick can be loaded from either side with ease.

Nine different shades of red brick are made and three of brown, the latter color being produced by mixing a salt of manganese with the clay as it enters the steel rollers to be crushed. About 100 different forms of special shape brick are made, one or two of which are sold as high as 65 cents each. The patterns or dies for each of these are owned by the company, and are kept in a separate fireproof building. The ordinary dry-pressed brick bring an average of about \$10.00 per thousand at the plant, while the special shapes average \$50.00. They have a wide distribution and a reputation second to none.

At the plant of the Huntingburg Dry-Pressed Brick Co., located at Huntingburg, Dubois County, the loess clay used (see page 285), is stored in sheds and from these passed through a pulverizer and then elevated to a rotary screen. It is then made into brick on a "U. S." brick machine. From the machine the brick are taken directly to the kilns, where they are "water-smoked" six days with wood and then burned at a white heat for an equal length of time. Four large Eudaly kilns, holding 128,000 each, and one smaller kiln, holding 65,000, are in use, this kiln capacity being sufficient to handle the output of the brick machine.

The dry-pressed brick made by the Huntingburg Co. in 1904 were being sold at \$5.00 per thousand, kiln run, f. o. b. at the plant. This is a very low price for brick of that quality, but in explanation it was said that the freight rate charged by the railway was so high that the brick had to be sold at that figure to meet competition. The output was 22,000 per day, which were shipped chiefly to East St. Louis and Centralia, Ill., New Albany and other points on the Southern Railway. Selected brick for front walls were bringing \$8.00 per thousand. The demand for both kinds during the year was far greater than the capacity of the plant could supply.

The Standard Brick Co., of Evansville, began in 1904 the making of dry-pressed stock brick from a carboniferous shale (see page 313). The shale is dumped from carts by the side of a Raymond 9-foot dry pan, where it is ground and then elevated and passed over a 24-foot gravity screen into a rotary mixer. From here it is taken to a Berg dry-pressed machine, which has a daily output of 20,000. The burning is done in four permanent covered clamp kilns, holding 400,000 each. The process, including water smoking, requires 16 days. Evansville slack coal, costing \$1.10 per ton laid down, is used as fuel.

At the plant of the Goetz Pressed Brick Co., just west of New Albany, Floyd County, the Knobstone shale used (see page 375) is dumped by tram car beneath sheds near a Williams pulverizer. After moistening, it is passed through the pulverizer or grinder, and then elevated and screened. From the screens it falls into a pit, where it is steamed, and from there it is made into brick on a Ross-Keller 6-mold dry-pressed machine, at the rate of 25,000 per day. Burning is done in two Swift grateless furnace kilns, holding 400,000 each, the foundations being in for two additional kilns of the same pattern. Coke is used for water smoking and coal for burning, the former process requiring ten and the latter twenty-four days.

The pressed brick made at the Goetz factory are bright cherry red in color, with sharp edges, and appear tough and durable. They are being sold mostly as stock brick, bringing \$6.00 per thousand at the plant. Slack coal from Pike County, costing \$1.30 per ton laid down, is used as fuel. Water is obtained from the city waterworks reservoir on top of the hill half a mile north of the plant. The output in 1904 was about 3,000,000, which was but half the capacity of the plant.

The factory of the Standard Brick Co., of Crawfordsville, is located by the side of the Monon Railway, about two miles north of the city (see page 345). The Knobstone shale used is dumped by the side of a Western rock crusher and Steadman disintegrator, through which it is passed. The ground shale is then elevated and screened and made into dry-pressed brick on a Simpson brick machine. Two kilns are used for burning, one being a permanent rectangular down-draft, lined with St. Louis fire brick,

and holding 165,000; the other a temporary kiln, holding 225,000. The burning is done in 14 days, the first six of which are devoted to drying or water smoking.

At the time of my visit, in May, 1904, the plant had not been operated for nearly two years, but samples of the front brick in the yard showed them to have been of a handsome and uniform dark red color, hard and with sharp edges. They sold at \$11.00 to \$14.00 per thousand at Indianapolis and many points in Indiana. In August, 1904, the plant was started up again and operated for three months, the output being sold mainly as a high-class building brick for \$8.00 per thousand. It will continue to put out the same grade of wares in the future.

The making of ornamental or architectural terra cotta of high grade, from clay, is quite a complicated industry, about 15 different steps or processes being necessary before the ware is ready for the structure for which it is intended. The terra cotta is made only as orders are received, each architect of a large building making his own designs and requisitions. These are submitted, in small scale drawings, to the terra cotta company. In their office the drawings of the architect are carefully enlarged to the size of the working model, due allowance being made for shrinkage in the burning of the clay. From these drawings plaster of Paris models are made by experienced workmen for all pieces needed in duplicate. These models are then used in casting plaster of Paris molds, which serve to give shape and detail of design to the future piece of clay terra cotta. Where but one or two pieces of a special design are wanted, they are usually molded direct from the clay by a clay modeling artist.

The only factory making architectural or structural terra cotta in Indiana is that of the Indianapolis Terra Cotta Company, whose plant is located by the side of the Big Four Railway, near Brightwood, a suburb of Indianapolis. This company began operations in 1884, and their wares are now well and favorably known in all the larger cities and towns within a radius of 250 miles. The clays used for the body of their wares come mainly from western Indiana, the principal one being an under-clay from beneath coal IV, secured at Brazil, Clay County.

At the Indianapolis factory the raw clay is mixed at the dry pan with nearly one-half of its bulk of burned and ground clay. This

is derived from culls, or "overs," from the factory, and from old saggars secured from the Peru Electric Manufacturing Company, and is added to give body to the new ware and render it less liable to crack in drying. The mixture, after being run through the dry pan, is elevated and passed over an inclined screen into a horizontal pug mill. On emerging from this it is cut into chunks, which, after undergoing a ripening process in a small, close room, are again put through the pug mill. The material is then stored in a similar room, from which it is taken as needed for use.

In the molding room the moist clay is pressed into the molds by hand. Each piece of terra cotta is left hollow, in order to give it a decreased weight, but the interior of the larger pieces is strengthened by cross partitions, built up by hand, the intervals between the partitions being about six inches square. The molds for small pieces can be used three or four times a day, the ware drying rapidly enough for the molds to be turned that often. The larger pieces often require a day or two before the mold can be turned or removed. The molds can be used only 30 to 40 times, and then go to the dump or "bone yard." A fortune awaits the man who invents a cheap process for re-enlivening, or rendering fit for re-use, the plaster of Paris in these old molds, which at present are wholly without value.

After smoothing and removing any defect, the ware is taken to steam heated dry rooms, where it is exposed to a temperature of about 100 degrees F. for a period ranging from two or three days to a week, depending upon its size. Each piece is then taken to the spray-room, where a jet of a fluid mixture of clays and other ingredients is evenly and uniformly spread over it with a large atomizer. The object of this spraying is to give the desired color to the burned ware. Clays from England, New Jersey and Ohio are used as the principal constituents of the spray or wash. The colors are designed to harmonize with the front brick or other material of the structure in which the terra cotta is to be used. Shades of gray, buff, red or brown are most in vogue.

After drying the spray, the ware is then taken to the burning kiln. In the Indianapolis factory five kilns are in use, four being cone-shaped muffle kilns, with a capacity of 12 to 35 tons of ware. In them the different pieces rest on slabs about 26 inches square, which form shelves in the kiln. These slabs are of fire clay, and

rest on fire clay props or posts, about six inches in diameter. The length of post determines the distance between the shelves, this distance depending upon the size of ware to be burned. After being filled, the doorway of the kiln is closed and sealed air-tight, and the fires then kindled in the arches or fire holes at the base. A slow fire is maintained for 72 hours, when it is changed to a full fire, which is kept up for 60 to 72 hours. The fires are then drawn and the kilns allowed to cool gradually, about a week being required for this process. West Virginia coal is used as fuel, a ton of coal being required for each ton of terra cotta. During the full fire a temperature of 1,800 degrees F. is maintained. Each kiln is fitted with peep holes, and both trial pieces and pyrometric cones are used to determine the stage of burning.

From the kiln the burned ware is taken, piece by piece, to the fitting room, where the pieces for any one contract are closely inspected and fitted together, after which they are loaded directly into the cars. No permanent fixed price is obtained for the output of the factory, a specified price being made for each contract received.

The ware made by the Indianapolis Terra Cotta Company weighs about 70 pounds per cubic foot, and has the crushing strength of granite. It withstands in the highest degree the action of rain, frost and fire, and is as strong and durable as any other building material known to architects. Wherever used it has given the best of satisfaction, and in recent years the company has had to turn down numerous orders, the demand being beyond the present facilities of the plant to supply.

Statistics of Dry Pressed Brick, Terra Cotta and Encaustic Tile Industries in Indiana, for the Year 1904.

NAME OF FIRM.	Location.	Began Operation.	Capital Invested.	Kind of Products.	No. and Kind of Kilns.	Total Kiln Capacity.	Output in 1904.	Value of Output.	No. of Hands and Worked Daily Wage.	No. of Months
Kulage Brick Works....	Hobart, Lake County..	1897	\$150,000	Pressed front and special design brick.	5 Rectangular down draft	1,500,000	11,000,000	\$100,000	\$2 25	60
Chicago Hydraulic Pressed Brick Co.	Porter, Porter County.	1890	280,000	Pressed front and special design brick.	14 Rectangular Grover patent.	1,820,000	6,898,000	75,880	\$1 75	90
Huntingburg Dry Pressed Brick Co.	Huntingburg, Dubois County.	1893	34,000	Dry pressed front and stock brick, fire brick	5 Eudaly square down draft.	677,000	5,458,000	27,290	\$1 50	22
Standard Brick Co.....	Evansville, -Vanderburgh County.	1904	25,000	Dry pressed stock brick	4 Rectangular lamp kilns	1,600,000	2,000,000	9,500	\$1 75	15
Goetz Pressed Brick Co.	New Albany, Floyd County.	1904	30,000	Dry pressed stock brick	2 Rectangular Swift grate-less furnace.	800,000	3,000,000	18,000	\$1 60	28
Standard Brick Co.....	Crawfordsville, Montgomery County.	1893	27,000	Dry pressed stock brick	1 Aisip up and down draft, one Windgarde.	390,000	1,250,000	10,000	\$1 50	17
National Tile Co.....	Anderson, Madison County.	1899	200,000	Encaustic tile.....	14 Plain up draft, pottery..	.....	.....	200,000	\$1 65	277
United States Encaustic Tile Works.	Indianapolis, Marion County.	1877	150,000	Encaustic tile.....	25 Plain up draft, pottery..	.....	.....	250,000	\$1 30	275
The Indianapolis Terra Cotta Co.	Indianapolis, Marion County.	1894	50,000	Architectural terra cotta	4 Muffle and one bag.	.....	.....	35,000	\$2 00	85

VI. THE MANUFACTURE OF ORDINARY BUILDING BRICK AND DRAIN TILE.

Ordinary brick and drain tile are the crudest forms of clay wares made in the State, and their manufacture requires but little, if any, technical skill. They form, however, a large proportion of the commercial output of such wares, and the aggregate sum invested in the business of their making is a large one.

In all the small factories the clays used in their structure are either plastic drift or sedimentary clays, both of which are comparatively common in all parts of the State. The only preparation which these clays usually receive is the tempering in crude pug mills. The bricks are either made by hand molding or on soft mud brick machines; the tile on a form of the auger machine especially adapted for the purpose. The drying of the bricks is accomplished by the air and sunshine in open yards, or in racks and pallets protected by sheds. The tile are dried in the latter manner.

The burning of tile usually takes place in round, down-draft kilns of small dimensions. The bricks are burned either in permanent clamp up-draft kilns, protected by sheds, or, in the smaller yards, in the old-fashioned temporary casing or scoving kilns, each of which is but a nine-inch wall put up around a green kiln and taken down after each burning. The clamp kilns are far superior, and in the long run more economical, as the labor of rebuilding the kiln at each burning is saved and a much larger percentage of the bricks burned are first class.

Shale is used for ordinary brick-making in five or six of the larger factories of the State, and also for drain tile making at the three large factories of the National Drain Tile Co., already described under the Hollow Goods Industry. At four of the shale brick factories stiff mud brick are made on auger machines, and the output dried before burning by artificial heat in tunnel driers. Only the factories making shale brick will be here treated, the larger ones, using surface clay or a mixture of surface clay and shales, having been quite fully described in section III under their proper county headings.

The largest factory making ordinary brick in the State is that of the Marion Brick Works, located at East Montezuma, Parke

County. The Carboniferous shale here used (see page 105) is dumped by tram cars into chutes leading to four 9-foot dry pans. After being ground it is elevated to gravity screens and from there passes through an American 18-foot pug mill into a Chambers stiff mud, end-cut brick machine, with automatic cut-off attached. This machine, it is claimed, will make 100,000 brick in nine hours, six men being required to take the brick from the belt conveyor as fast as made and place them on iron cars. The drying is done in 60 hours by a steam-heated progressive tunnel, 60,000 feet of one-inch steam pipe being in use. In July, 1904, the burning was done in nine permanent kilns, holding 350,000 each, six of which were "Swift" kilns, while three were fitted up with the Boss system. In addition to these, two down-draft kilns, holding 85,000 each, were in use. In the Swift kilns the burning requires 12 to 14 days, while by the Boss system the time is shortened to seven and a half days. Mecca six-inch screened lump coal, costing \$1.95 laid down was being used in the boilers; and slack, costing \$1.30 per ton in the kilns, 40 tons of the former and 90 of the latter being used each day.

The plant is operated by three engines and seven boilers, viz., one 125-horsepower Atlas, one 250-horsepower Erie and one 60-horsepower Alfrey, the latter being connected with dynamo for electric lighting. The water supply is pumped from Leatherwood Creek, raised 150 feet and stored in two large tanks on top of the hill just south of the factory. Storerooms, blacksmith and repair shops and other adjuncts of a modern factory are present. The plant is run the year around, and is behind in its orders for most of the time. The output is a strong and durable building brick, which brings \$6.25 to \$6.50 per thousand f. o. b. the cars.

At the plant of the Sheridan Brick Works, two miles north of Brazil, the shale used (see page 189) is dumped from tram cars by the side of three 9-foot dry pans. From these it passes to two Potts and one Wooley soft mud brick machines, ten men being required to operate each. The drying is done in a standard steam-heated, 24-track progressive tunnel, 122 feet in length, and requires 48 hours. Eight up-draft Swift kilns, holding 400,000 each, are used for burning. These are permanent kilns, protected by sheds, and have tracks for small coal cars along the sides, the coal being unloaded into the smaller cars, which are

pushed wherever needed. The process of water smoking and burning takes 14 days. Brazil coal is used as fuel, 80 tons being consumed daily in operating the entire plant. Power is furnished by a 250-horsepower Atlas engine and a battery of five boilers. Four Fairbanks & Dean pumps are in use to remove water from the drier and feed the engine. Blacksmith and repair shops and bath room for the employes are attached. The plant is operated during the entire year. The brick are hard, tough and of a handsome red color. They are shipped mainly to Indianapolis, bring \$5.75 to \$6.00 per thousand f. o. b. at the plant, and the demand is always in excess of the supply.

At the plant of the Hoosier Brick Co., two miles west of New Albany, the Knobstone shale used (see page 375), is dumped from tram cars by the side of a 9-foot dry pan. After grinding it is elevated and passed over an inclined screen to a Freese stiff mud auger brick machine with automatic cut-off attached. Drying is done in a steam-heated tunnel drier for 24 hours. Five kilns are used in burning, three being square, down-draft, holding 150,000 each; one a round down-draft, holding 45,000, and one a square up-draft, with a capacity of 330,000. Water smoking is done with wood, and takes five days. Boonville slack coal, costing \$1.20 a ton laid down, is used for burning, which requires seven days additional. The output of the factory in 1904 was 5,050,000. They were shipped mainly to points tributary to the Southern Railway in Southern Indiana and Kentucky.

At the plant of the Cayuga Brick & Coal Co. the shale used (see page 130) is dumped from tram cars by the side of two 9-foot Stevenson dry pans. After grinding and screening, it is passed through a 12-foot pug mill, and is made into stiff mud brick on an American auger machine, with automatic cut-off attached. After repressing, the brick are dried either by steam in a four-track tunnel, 189 feet in length, or by waste heat in three four-track tunnels, 100 feet in length. Forty-eight hours are required by the former process and 36 by the waste heat process. Burning is done in eight rectangular Eudaly kilns, which hold an average of 145,000 each, the process taking nine days, two of which are devoted to water smoking. From 65 to 70 per cent. of "firsts" are secured from each kiln. These bring \$10 per thousand at the plant for use as front brick, most of them being

shipped to Chicago. The seconds bring \$4.00 per thousand for ordinary use.

At the plant of the Acme Brick Works, near Cayuga, Vermillion County, the shale (see page 128) is dumped by the side of a Frey-Sheckler dry pan. After grinding, screening in a 20-foot gravity screen and pugging, it is made into stiff mud brick on a Wallace "Intermediate" machine, with automatic cut-off. The brick are dried by direct heat for 24 hours in eight single-track tunnels. For burning eight days are required, twelve 28-foot round down-draft kilns being in use. Cates coal, costing \$1.75 for lump or \$1.50 for mine run, is used for fuel. The brick on the yard were light cherry red in color, very hard and non-porous, and were having a ready sale at \$6.00 per thousand on board cars at the plant.

At Newport, Vermillion County, all-shale brick are being made in the new plant of the Newport Brick & Clay Co. The shale (see page 132) is dumped by the side of a 9-foot dry pan, then elevated, screened and pugged, and made into stiff mud brick on a Wallace Little Wonder machine, with Raymond automatic cut-off. The brick are, for the most part, repressed, then dried on a "hot floor" of cement by waste steam for 36 to 42 hours. Burning is done in seven to nine days in six square, down-draft kilns, holding 150,000 each. Clinton coal, costing \$2.00 per ton laid down, is used as fuel. The brick are hard, tough and durable, and find a ready market.

Drain Tile Factories of Indiana.—A number of factories are engaged in making drain tile on an extensive scale in Indiana. The pioneer of these, the Summitville plant of the National Drain Tile Co., has been fully described.* Several others, almost as large, which use surface clays as the raw material, were not visited on account of lack of time. The statistics regarding their output, etc., will, however, be found in the table at the end of the paper under the heading "Statistics of Ordinary Building Brick and Drain Tile." The only three which will be mentioned briefly in this connection are those of the National Drain Tile Co., at Montezuma, Hillsdale and Terre Haute.† "In dimensions the Hillsdale and Terre Haute plants are the same, 208x80 feet,

* See under-clays of Madison Co., p. 424.

† For location, character of shales used, etc., at each of these plants, see under-clays of Parke, Vermillion and Vigo Counties. pp. 106, 144, 161.

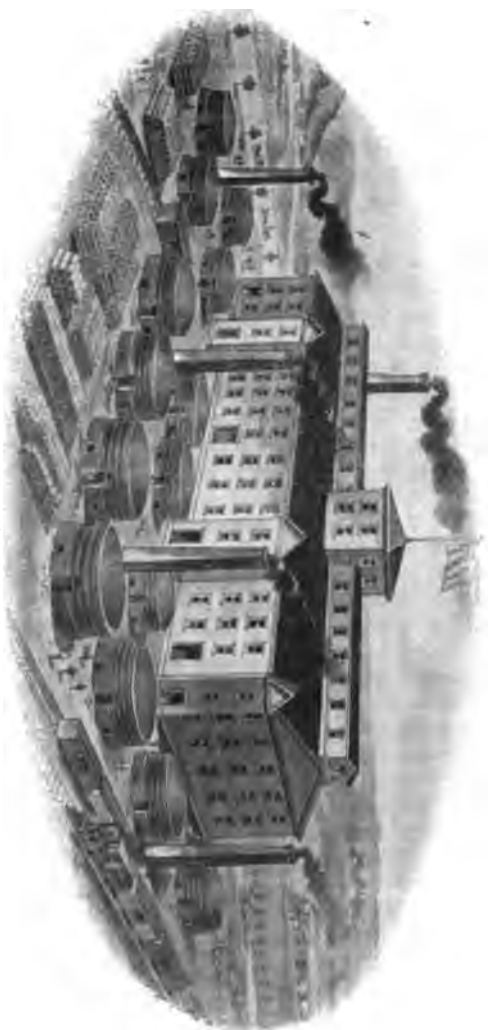
and three stories high, with engine, boiler and machinery rooms, 128x40 feet, adjoined, while the Montezuma plant is smaller. The Terre Haute factory is solidly built of concrete and hollow building block, fitted with the latest improved machinery, heated by steam and lighted by acetylene gas, while the other two are frame, the one at Hillsdale having dynamo for lighting and pumping. At each of these plants the tile are made by the same process, the shale being dumped by tram cars into chutes leading into a Taplin-Rice steel dry pan, where it is ground. From there it is elevated to the third or fourth floor and passed over screens, thence to the pug mill, thence to a conveyor, which is reversible in its movements, carrying the shale, at the will of the operator, either to one of Madden & Co.'s auger machines or to a Taplin-Rice steam press, according to whether small or large tile are to be made, four to seven-inch being made on the Madden machine, while eight to 30-inch are made on the steam press." Eight men are required at each of the larger presses in making the tile, conveying them to dry floors and rounding up the ends.

At each of the factories the wares are dried on steam-heated sewer pipe floors. At Hillsdale and Terre Haute the three dry floors are 80x208 feet in size, and hold 2,600 16-inch tile. The drying takes from seven to nine days, the temperature averaging 80° in winter and 110° in summer in each room. The lower floors are laid on concrete sills, 3x3 feet in size. On top of these are 4x8-inch oak sills, on which rest uprights of Southern pine, 12 inches square, supporting the upper floors. Burning is done in standard 30-foot round down-draft kilns. Ten of these are in use at the Montezuma plant and 14 each at the Hillsdale and Terre Haute plants. Each kiln holds about \$450 worth of tile, the small size being nested in the larger ones. A kiln each day is the average output of each of the two larger plants, this average being kept up for months at a time. At the Montezuma plant, Mecca coal, costing \$1.95, and at the Hillsdale plant Clinton coal, costing \$1.40 per ton laid down, is used.

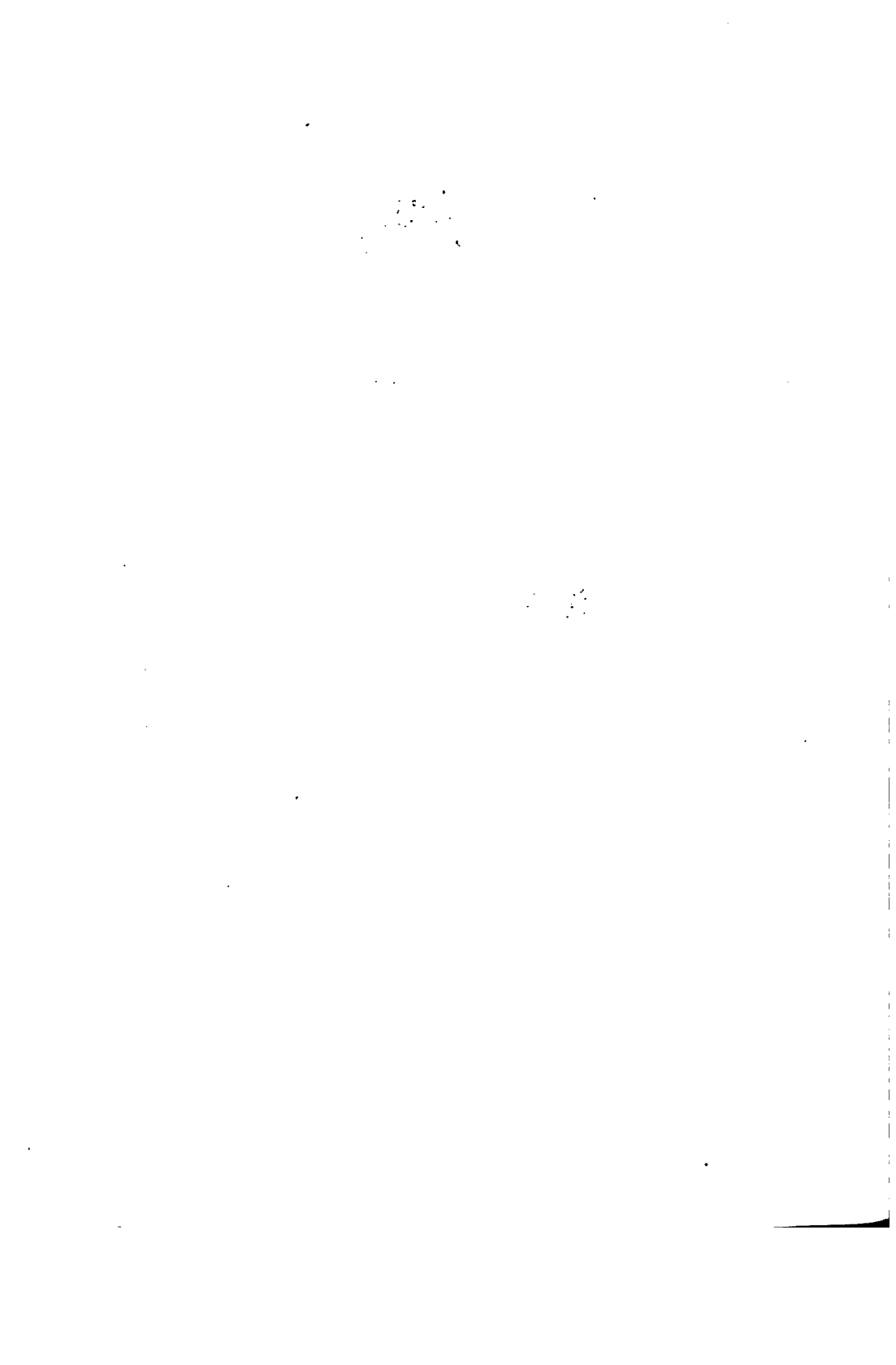
The facilities of the National Drain Tile Co. for manufacturing and shipping tile cannot be surpassed, and their wares have a large sale and a wide reputation for excellence of quality.

In order to secure as full statistics as possible relative to the

Pl. XXXIV.



Plant of National Drain Tile Company, located two and a half miles northwest of Terre Haute, Vigo County.



manufacture of ordinary building brick and drain tile in each county of the State, a copy of the following blank form was mailed to each manufacturer whose yard was not visited in person:

STATISTICS OF THE CLAY INDUSTRIES OF INDIANA.

1. Name of firm or individual.....
2. Location
3. Began operations in what year?.....
4. Nature and thickness of clays used—surface clay? shale?
under-clays?
5. Character and thickness of stripping.....
6. Amount of capital invested.....
7. Kinds of materials made.....
8. Number and kind of kilns.....
9. Kiln capacity.....
10. Kinds of machinery used.....
11. Methods of drying products.....
12. Annual output in 1904; if brick, number of thousand.....
13. Value of products in 1904.....
14. Number of hands employed in 1904.....
15. Average daily wages paid in 1904.....
16. Number of months worked in 1904.....

From the returns and the data gathered personally the following table has been prepared, which contains, in condensed form, the more important statistics regarding the building brick and drain tile industry in the State for the year 1904:

Statistics of Ordinary Building Brick and Drain Tile Industry in Indiana for 1904.

ADAMS COUNTY.

NAME OF FIRM OR INDIVIDUAL.	Location.	Capital Invested.	How Moulded.	How Dried.	Output of Brick in 1904.	Value of Brick.	Value of Tile.	No. of Hands and Daily Wage.	No. of Months Worked.
Krick, Tyndall & Co	Decatur	\$12,000	Mock brick machine; Mad- den tile machine; Taplin & Rice steam press.	Sheds and pallets for brick; waste heat for tile.	600,000	\$4,500	\$28,500	30 \$1 50	8
J. H. Elick	Decatur	6,000	E. M. Freese machine	Sheds and pallets .....	.....	.....	3,700	3 \$1 50	7
Margaret Mayer	Decatur	6,000	Anderson brick machine..	Sheds and pallets	600,000	4,500	.....	18 \$1 40	5
Andrew Gottschalk	Berne	6,000	New Departure tile ma- chine.	Sheds and pallets .....	.....	.....	6,000	8 \$1 35	8
Levellen & Smith	Monroe	7,000	Fate tile machine	Goodwin hot floor and sheds and pallets.	.....	.....	4,000	8 \$1 25	7

ALLEN COUNTY.

Ft. Wayne Brick and Tile Co.	Ft. Wayne	\$30,000	Potts' brick machine.....	Sharer patent dryer..	4,000,000	\$25,000	.....	30 \$1 75	8
Wm. Moellering & Sons..	Ft. Wayne	30,000	.....	Sheds and pallets.....	3,100,000	17,050	.....	25 \$2 00	64
John C. Braun	Ft. Wayne	5,000	By hand.....	Sheds and pallets....	1,200,000	6,500	.....	12 \$2 50	6
Chas. W. Getz & Co	Ft. Wayne	10,000	— soft-mud brick machine.	Sheds and pallets.....	1,300,000	7,150	.....	12 \$1 87	54
Wm. Miller	Ft. Wayne	3,000	By hand.....	Sheds and pallets.....	1,200,000	7,300	.....	12 \$2 00	6
J. A. Koehler	Ft. Wayne	7,000	Potts' soft-mud brick machine.	Sheds and pallets.	1,300,000	6,500	.....	9 \$2 00	5
Wallen Tile and Milling Co.	Wallen.....	4,000	New Departure tile mill ...	Sheds by air .....	.....	.....	\$3,500	6 \$1 50	7
Woodburn Tile and Brick Co.	Woodburn.....	20,000	J. D. Fate tile machine; Freese tile and brick machine.	Sheds by air	300,000	1,800	2,200	15 \$1 50	2

Statistics of Ordinary Building Brick and Drain Tile Industry—Continued.

BARTHOLOMEW COUNTY.

NAME OF FIRM OR INDIVIDUAL.	Location.	Capital Invested.	How Moulded.	How Dried.	Output of Brick in 1904.	Value of Brick.	Value of Tile.	No. of Hands and Daily Wage.	No. of Months Worked.
F. T. Crump.	Columbus.	\$30,000	Horton brick machine.	Tunnel dryer, by ex- haust steam.	2,000,000	\$12,000	.....	25 \$1 50	6
Wm. R. Smith & Son.	Columbus.	1,000	By hand.	Open yard.	400,000	2,400	.....	8 \$1 75	6
Chas. D. Glick.	Seven miles S. E. of Columbus.	3,000	Madden No. 5 B auger ma- chine.	Shed and pallets. ....	.....	.....	\$1,750	4 \$1 10	3½
John C. Burns.	Elizabethtown.	2,000	— tile machine.	Sheds and pallets. ....	.....	.....	2,000	4 \$1 00	6
R. D. Stam.	Near Hope.	5,000	Horton, Hercules brick ma- chine.	?	600,000	3,600	.....	10 \$1 40	2
Miller & Rominger.	Hope.	10,000	Hansen tile mill.	Sheds and pallets. ....	.....	.....	5,000	12 \$1 50	7
Geo. H. Daum.	Columbus.	1,500	One auger tile mill.	Sheds, by air.	80,000	480	2,000	4 \$1 25	8

BENTON COUNTY.

J. J. Holtam.	Earl Park.	\$20,000	J. D. Fate brick and tile machine.	Sheds and pallets and on floors with steam.	500,000	\$3,000	\$4,000	14 \$1 75	8
Wm. Lawson.	Otterbein.	6,000	Little Wonder tile machine	Sheds and pallets. ....	.....	.....	5,100	4 \$1 60	7

BLACKFORD COUNTY.

Clark Croninger.....	Hartford City.....	\$20,000	American auger machine..	Dry floors, by steam...	\$20,000	20 \$1 75	11
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BOONE COUNTY.

Kersey Bros.....	Hazeltig.....	\$2,000	— auger tile machine..	Sheds and pallets.....	\$2,200	6 \$1 60	6
Lebanon Brick Works...	Lebanon.....	10,000	Anderson brick machine..	Sheds and pallets.....	1,200,000	\$9,400	16 \$1 60	6
Wicker Bros.....	Lebanon.....	1,500	Chandler & Taylor tile machine.	Sheds and pallets.....	.....	1,400	3 \$1 25	5
J. A. Bassett.....	Lebanon.....	1,200	By hand.....	Open yard.....	600,000	3,500	6 \$1 75	6
Saunders & Robinson	Seven miles N. E. of Lebanon.	4,000	Anderson auger tile machine.	Sheds and pallets.....	.....	3,000	10 \$1 30	8

CARROLL COUNTY.

H. H. Landis	Bringhamur.....	\$2,000	Penn No. 8 tile mill	Drying shed with shutters.	\$1,000	6 \$1 50	4
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CASS COUNTY.

Jno. E. Barnes & Sons ...	Logansport.....	\$18,000	Quaker brick machine	Sheds and pallets	2,000,000	\$18,000	25 \$1 75	5
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CLARK COUNTY.

Jeffersonville Brick Co...	Jeffersonville.....	\$12,000	E. M. Fresse auger machine	Sheds and pallets.....	1,000,000	\$5,750	27 \$1 40	4
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Statistics of Ordinary Building Brick and Drain Tile Industry—Continued.

CLAY COUNTY.

NAME OF FIRM OR INDIVIDUAL.	Location.	Capital Invested.	How Moulded.	How Dried.	Output of Brick in 1904.	Value of Brick.	Value of Tile.	No. of Hands and Daily Wage.	No. of Months Worked.
Sheridan Brick Works ...	Brazil	\$100,000	Two Potts and one Woolley soft mud brick machine.	Standard tunnel dryer, by steam.	13,000,000	\$53,500	.....	100 \$1 75	10
"Excelsior Clay Works ...	Brazil .....	.....	Hoosier brick machine....	Tunnel dryer, by steam	100,000	500	.....	.....	.....
Clay City Brick and Clay Co.	Clay City	25,000	Fate stiff mud auger ma- chine.	Tunnel dryer, by direct heat.	1,000,000	6,250	.....	12 \$1 50	8
Geo. J. Kaiser	Clay City	2,000	Little Wonder tile machine.	Sheds and pallets	120,000	720	\$1,580	3 \$1 50	6

"See under "Statistics of Sewer Pipe, Hollow Goods," etc.

CLINTON COUNTY.

M. J. Lee Drain Tile Co..	Colfax	\$40,000	Taplin-Rice drain tile press; Brewer-tile ma- chine.	Dry floors, by steam...	.....	.....	\$36,500	30 \$1 65	12
J. B. Lowden	Michigantown	3,000	Little Wonder tile machine	Dry floors, by steam...	.....	.....	2,400	6 \$1 35	6
Frankfort Brick and Construction Co.	Frankfort	21,000	Potts soft mud brick ma- chine.	Sheds and pallets	2,000,000	\$12,000	.....	20 \$1 50	7
B. F. Alter & Son	Forest	1,000	Frankfort tile mill	Sheds and pallets .....	.....	.....	500	3 \$1 00	3

Statistics of Ordinary Building Brick and Drain Tile Industry—Continued.

DEKALB COUNTY.

NAME OF FIRM OR INDIVIDUAL.	Location.	Capital Invested.	How Moulded.	How Dried.	Output of Brick in 1901.	Value of Brick.	Value of Tile.	No. of Hands and Daily Wage.	No. of Months Worked.
W. D. Miller.....	Auburn	\$4,000	Ohio tile mill	Sheds and pallets .....	.....	.....	\$3,000	\$1 50 6	6
Grogg Bros	Auburn	2,500	Anderson brick machine...	Sheds and pallets	500,000	\$3,000	.....	12 \$1 50	34
Blum & Son.....	Moore	4,000	.....	On floor of shed .....	.....	.....	2,000	8 \$1 50	6
Herman Groscoop	Altona	3,000	Anderson New Departure tile machine.	Sheds and pallets .....	.....	.....	2,500	6 \$1 50	7
Fred Groscoop	Garrett.....	6,000	Anderson brick machine...	Sheds and pallets	800,000	4,800	.....	15 \$1 35	6

DELAWARE COUNTY.

Bennett Brick Co.....	Muncie.....	\$25,000	Hercules brick machine....	Tunnel dryer, by di- rect heat.	3,000,000	\$20,000	.....	25 \$1 55	6
J. D. Mock Brick Co.....	Muncie.....	25,000	J. F. Mock brick machine...	Tunnel dryer, by di- rect heat.	4,000,000	24,000	.....	25 \$1 75	10
Studebaker & Son	Shideler.....	5,000	Anderson tile machine....	On floor, by steam .....	.....	.....	\$3,000	5 \$1 50	8

DUBOIS COUNTY.

Wm. Lukemeyer	Huntingburg	\$2,500	E. M. Freese brick and tile machine.	Sheds and pallets .....	.....	\$2,400	7 \$1 50	5
Bookling Bros	Huntingburg	2,000	By hand.	Sheds and pallets	880,000	\$3,100	6 \$1 50	7

ELKHART COUNTY.

Goshen Brick Co.	Goshen	\$10,000	Potts' soft mud brick machine.	Sheds and pallets	800,000	\$5,000	15 \$1 50	6
Bemenderfer Brick Co ..	Goshen	5,000	.....	Sheds and pallets	500,000	3,500	12 \$1 50	4
Elkhart Brick Co.	Elkhart	3,000	No. 2 American brick machine.	Sheds and pallets	2,300,000	10,925	24 \$1 75	6
John C. Boss	Elkhart	20,000	Fate stiff mud auger machine.	.....	.....	.....	.....	...

PAYETTE COUNTY.

A. Fries & Sons	Connersville	\$15,000	Auger tile machine; 1 soft mud brick machine.	Tile on floor, steam racks and pallets.	1,000,000	\$6,000	15 \$1 40	8
C. P. Ariens	Connersville	2,000	Quaker brick machine	Sheds and pallets	200,000	1,200	5 \$1 50	2

FLOYD COUNTY.

Hooster Brick Co.	New Albany	\$40,000	Freese stiff mud brick machine.	Tunnel dryer by steam	5,050,000	\$32,000	33 \$1 50	8
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Statistics of Ordinary Building Brick and Drain Tile Industry—Continued.

FOUNTAIN COUNTY.

NAME OF FIRM OR INDIVIDUAL.	Location.	Capital Invested.	How Moulded.	How Dried.	Output of Brick in 1904.	Value of Brick.	Value of Tile.	No. of Hands and Daily Wage.	No. of Months Worked.
H. H. Prather.....	Covington	\$3,000	Brewer tile machine	Sheds and pallets	40,000	\$300	\$1,600	\$1 40	6
James A. Furr.....	Steam Corner	2,000	E. M. Freese tile machine..	Sheds and pallets .....	.....	.....	2,000	\$1 50	9
S. P. Cowgill.....	Kingman	5,000	.....	Sheds and pallets	60,000	360	2,840	\$1 50	6
Daniel Carpenter.	Mellott	2,000	Madden & Co. tile mill.....	Sheds and pallets .....	.....	.....	1,000	\$1 25	4

FRANKLIN COUNTY.

A. Fries & Sons.....	Brookville.....	\$3,000	One soft mud brick machine.	Sheds and pallets	650,000	\$4,000	.....	\$1 35	24
Noah B. Waggoner	Blooming Grove.....	2,000	Madden & Co. tile machine	Sheds and pallets .....	.....	.....	\$1,500	\$1 25	4

FULTON COUNTY.

A. A. Gast	Akron	\$15,000	B. M. Freese tile mill; Wellington brick machine.	Tile by steam; brick in sheds and pallets.	700,000	\$4,000	\$7,000	\$1 50	9
A. A. Gast	Mets	5,000	Fate brick and tile machine	Sheds and pallets .....	.....	.....	3,000	\$1 40	9
Swick & Meredith	Fulton	2,500	Freese tile machine	Sheds and pallets .....	.....	.....	2,200	\$1 40	5

GIBSON COUNTY.

W. M. Read	Princeton	\$9,000	Potts' soft-mud brick machine.	Sheds and pallets	1,700,000	\$8,500	.....	16 \$1 50	8
Jesse Mitchell	Princeton	5,000	Quaker brick machine	Sheds and pallets	1,200,000	6,000	.....	16 \$1 50	8
Stormont Bros	Francisco	3,000	Little Wonder tile and brick machine.	Sheds and pallets	100,000	700	\$600	2 \$1 25	8
Chas. Read	Oakland City	4,000	Quaker brick machine	Sheds and pallets	400,000	2,000	.....	13 \$1 50	2
Polk Clay Working Co	Fort Branch	5,000	Kell tile machine; Quaker brick machine.	Sheds and pallets	500,000	3,000	500	8 \$1 37	8

GRANT COUNTY.

Bolen Brick Co	Marion	\$20,000	By hand	Sheds and pallets	2,169,000	\$15,000	.....	45 \$2 00	6
Marion Brick Works	Marion .....	.....	Three Potts' soft-mud brick machines.	Barron tunnel dryer, by steam.	19,208,000	78,000	.....	80 \$1 85	9
Citizens Brick Co	Jonesboro	18,000	Potts' soft-mud brick machine.	Standard tunnel dryer, by steam.	4,000,000	20,000	.....	17 \$1 80	8
Sweetser Drain Tile Co	Sweetser	20,000	One New Departure tile machine; one Madden tile machine.	Dry floors, by steam .....	.....	.....	\$20,000	11 \$2 00	12
Fairmount Tile Co	Fairmount	15,000	.....	Dry floors, by steam .....	.....	.....	25,000	20 \$1 50	8
Herbst Drain Tile Co	Herbst	15,000	.....	Dry floors, by steam .....	.....	.....	25,000	25 \$1 50	8
J. and E. Fowler	Fowlerston	2,500	One auger tile mill	Dry floors, by gas .....	.....	.....	1,000	3 \$1 50	5
Jno. Clifton Sons	Matthews	20,000	Potts' soft-mud brick machine.	Hot floor, by gas	500,000	3,000	.....	35 \$1 75	1

Statistics of Ordinary Building Brick and Drain Tile Industry—Continued.

GREENE COUNTY.

NAME OF FIRM OR INDIVIDUAL.	Location.	Capital Invested.	How Moulded.	How Dried.	Output of Brick in 1904.	Value of Brick.	Value of Tile.	No. of Hands and Daily Wage.	No. of Months Worked.
Worthington Brick and Tile Co.	Worthington	\$5,000	One soft-mud brick ma- chine; one stiff-mud tile machine.	Sheds and pallets	225,000	\$1,350	\$350	14 \$1 25	2
C. W. Baughn	Bushrod	4,100	Freese tile machine	Sheds and pallets	50,000	300	2,290	5 \$1 25	8
O. Shelton	Switz City	1,800	Fate tile machine	Sheds and pallets .....	.....	.....	1,200	4 \$1 25	6
Linton Brick Mfg. Co.	Linton	3,500	Anderson brick machine	Sheds and pallets	1,250,000	8,457	.....	14 \$2 00	7
Smith & Smith	Midland	500	By hand	Open yard	300,000	1,900	.....	6 \$1 35	6
Aschman Bros.	Jasonville	700	By hand	Sheds and pallets	500,000	3,250	.....	9 \$2 00	5

HAMILTON COUNTY.

Lacy Seed & Fuel Co.	Noblesville	\$3,000	By hand	Sheds and pallets	400,000	\$3,000	.....	9 \$1 75	7
Arcadia Brick Works	Arcadia	40,000	Potts' soft-mud brick ma- chine.	Standard tunnel dryer, by steam.	6,000,000	30,000	.....	40 \$1 75	7
Chas. Jessup	Arcadia	1,500	E. M. Freese auger mill	Sheds, by air .....	.....	.....	\$700	3 \$1 20	3

HANCOCK COUNTY.

Greenfield Brick Works..	Greenfield.....	\$10,000	Potts' soft-mud machine....	Sheds and pallets.....	3,500,000	\$19,250	.....	30 \$1 75	6
Wm. Reasoner.....	Gem.....	2,000	Eureka tile machine.....	Sheds and pallets.....	.....	.....	\$1,800	3 \$1 25	6
Elmer Knight.....	Maxwell.....	1,000	.....	Sheds and pallets.....	.....	.....	1,300	2 \$1 25	4
Madison Brick Co.....	Shirley.....	15,000	Potts' soft-mud brick machine.	Sheds and pallets, by gas.	1,800,000	12,000	.....	25 \$1 80	6

HENDRICKS COUNTY.

Lingeman Bros.....	Brownsburg.....	\$5,000	Little Wonder tile and brick machine.	Sheds and pallets.....	.....	.....	\$5,000	7 \$1 37	8
E. R. Ellis.....	Coatesville.....	3,500	.....	Sheds and pallets.....	.....	.....	3,500	8 \$1 25	7
G. B. Pruitt.....	Coatesville.....	.....	By hand.....	Open yard.....	100,000	\$600	.....	7 \$1 25	1
Boyd Tile Works.....	Hazelwood.....	5,000	Chandler & Taylor tile machine.	Sheds and pallets.....	.....	.....	3,600	7 \$1 20	6
Jas. W. Beek.....	Danville.....	2,000	Quaker brick machine.....	Sheds and pallets.....	200,000	1,200	.....	11 \$1 50	7
Wm. I. Gill.....	North Salem.....	1,000	By hand.....	Open yard.....	280,000	1,680	.....	2 \$1 60	64

HENRY COUNTY.

New Castle Brick & Tile Co	New Castle.....	\$12,000	Quaker brick machine, Madden tile machine.	"Outdoor Scott system"	800,000	\$4,800	\$2,200	12 \$1 50	5
Nathaniel Edwards.....	Grant City.....	5,000	New Departure tile machine.	Dry floors, by natural gas.	.....	.....	3,000	8 \$1 40	7

Statistics of Ordinary Building Brick and Drain Tile Industry—Continued.

HOWARD COUNTY.

NAME OF FIRM OR INDIVIDUAL.	Location.	Capital Invested.	How Moulded.	How Dried.	Output of Brick in 1904.	Value of Brick.	Value of Tile.	No. of Hands and Daily Wage.	No. of Months Worked.
J. M. Leach & Co.	Kokomo.	\$80,000	Potts' soft-mud brick machine.	Tunnel dryer, by hot air.	5,760,000	\$37,440	.....	38 \$1 75	8
Stephen Colescott.	Greentown.	4,000	Potts' brick machine, New Departure tile mill.	Sheds and pallets	.....	.....	\$3,000	7 \$1 50	3
Richard Cunningham	New London.	2,000	One sugar tile mill.	Sheds and pallets.	20,000	120	745	2 \$1 25	5

HUNTINGTON COUNTY.

Bippus Drain Tile Co.	Bippus.	\$11,000	J. D. Fate brick and tile machine.	Sheds and pallets. ....	.....	.....	\$6,000	10 \$1 75	5
Tribolet Bros.	Five miles S. E. of Huntington.	5,000	Little Wonder tile and brick machine.	Sheds and pallets.	200,000	\$1,200	5,400	7 \$1 25	7
Holsinger Brick Co.	Huntington.	7,500	Anderson Chief brick machine.	Sheds and pallets.	1,150,000	6,500	.....	19 \$1 75	54
Shideler & Mahoney.	Majestic.	5,000	Madden tile mill.	Sheds and pallets.	50,000	400	3,000	6 \$1 25	64

JACKSON COUNTY.

Henry H. Kooner.....	Crothersville	\$1,000	By hand.....	Open yard.....	300,000	\$1,500	.....	5	\$1 50
Geo. M. Ebaugh	Seymour	2,000	Tiffen brick and tile machine.	Sheds and pallets.....	100,000	500	\$800	4	\$1 00
W. L. Kasting.....	Seymour	5,000	Potts' brick machine.....	Sheds and pallets.....	1,000,000	6,000	.....	15	\$1 50
Brownstown Brick and Tile Co.	Brownstown	4,000	— brick and tile machine.	Sheds and pallets.....	450,000	2,700	.....	7	\$1 50
Kurtz Brick and Tile Co..	Kurtz	2,000	Freese brick and tile machine.	Sheds and pallets.....	225,000	1,462	.....	7	\$1 25

JASPER COUNTY.

Green & Bowman.....	Remington	\$9,000	Adrian tile machine	Sheds and pallets.....	\$6,000	7
Jas. F. Irwin & Son	Rensselaer.....	5,000		Sheds and pallets.....	6,500	7
Alter & Wolfe.....	Rensselaer.....	4,000	New Departure tile machine	Sheds and pallets.....	4,000	7
J. I. Miller.....	Pleasant Grove.....	6,000	Wallace tile machine	Sheds and pallets.....	5,000	6
					\$1 50	7
					\$1 50	7
					\$1 35	7
					\$1 50	6

Statistics of Ordinary Building Brick and Drain Tile Industry—Continued.

JAY COUNTY.

NAME OF FIRM OR INDIVIDUAL.	Location.	Capital Invested.	How Moulded.	How Dried.	Output of Brick in 1904.	Value of Brick.	Value of Tile.	No. of Hands and Daily Wage.	No. of Months Worked.
Portland Tile and Hollow Building Block Works.	Portland	\$30,000	Auger mill and steam sewer pipe press.	Dry floors, by steam and gas.	.....	.....	\$45,000	30 \$1 50	10
Martin Bros.	Greene	4,000	E. M. Freese tile machine.	Sheds and pallets.	.....	.....	1,200	4 \$1 50	6
Jas. A. Byrd	Boundary	4,000	Buckeye tile machine.	Sheds and pallets.	.....	.....	3,000	6 \$1 50	8
Henry L. Huey	Portland	3,000	Brewer tile machine.	Sheds and pallets.	.....	.....	1,700	2 \$1 25	5
Redkey Tile and Building Block Co.	Redkey	20,000	Fate tile machine.	In sheds by gas.	.....	.....	10,000	10 \$1 75	12
Shaw, Rhodes & Singer.	Bryant	3,000	Titus tile machine.	Sheds and pallets.	.....	.....	2,000	4 \$1 50	6
F. M. Byrd & Son	New Mount Pleasant	2,000	Buckeye tile mill.	Sheds and pallets.	150,000	\$900	1,600	3 \$1 50	6

JEFFERSON COUNTY.

Joseph Heck Co.	Madison	\$5,000	Freese brick machine.	Sheds and pallets.	700,000	\$4,900	.....	9 \$1 50	6
Ross & Kimmel	Madison	4,000	Chambers brick machine.	Sheds and pallets.	200,000	1,200	.....	3 \$1 50	6

JENNINGS COUNTY.

Simmons & Son.....	North Vernon	\$1,500	By hand.....	Open yard.....	500,000	\$2,750	.....	8
Harry Harms	North Vernon	2,000	By hand.....	Open yard.....	450,000	2,250	.....	5
								\$1 50
								\$1 60

JOHNSON COUNTY.

Land & Britton.....	Nineveh.....	\$2,500	Eureka tile and brick machine.....	Sheds and pallets.....	70,000	\$420	\$930	7
E. O. Halstead	Franklin.....	5,000	By hand.....	Sheds and pallets.....	400,000	2,800	.....	6
Jas. F. Davis.....	Franklin.....	4,000	By hand.....	Sheds and pallets.....	400,000	3,000	.....	6
Dickson Bros.....	Whiteland.....	10,000	Madden tile machine.....	Sheds, by steam.....	.....	.....	8,000	4
T. J. Spears	Greenwood	2,000	By hand.....	Sheds and pallets.....	400,000	2,800	.....	6
Jno. H. Warner.....	Franklin.....	2,000	By hand.....	Open yard.....	250,000	1,250	.....	4
								\$1 25

Statistics of Ordinary Building Brick and Drain Tile Industry—Continued.

KNOX COUNTY.

NAME OF FIRM OR INDIVIDUAL.	Location.	Capital Invested.	How Moulded.	How Dried.	Output of Brick in 1904.	Value of Brick.	Value of Tile.	No. of Hands and Daily Wage.	No. of Months Worked.
Wm. F. Koch	Bicknell	\$5,000	Monarch brick machine....	Sheds and pallets	1,340,000	\$8,500	.....	14 \$1 87	6
Wm. F. Koch	Westphalia	5,000	Adrian tile machine.....	Sheds and pallets .....	.....	.....	\$2,500	7 \$1 75	4
S. Kixmiller	Vincennes	10,000	Quaker soft-mud brick ma- chine.	Sheds and pallets	1,500,000	7,500	.....	20 \$1 75	6
S. Kixmiller & Co	Vincennes	5,000	Quaker brick machine	Sheds and pallets	2,000,000	10,000	.....	25 \$1 75	6
Jno. B. Prullage.....	Vincennes	8,000	— soft-mud brick ma- chine.	Tunnel dryer, by steam	2,500,000	13,750	.....	22 \$1 70	10
Peter Bonewits	Monroe City	4,000	Quaker brick machine	Sheds and pallets	500,000	2,500	.....	12 \$1 35	4
Chas. Meyer.....	Freelandville.....	2,000	Monarch brick machine....	Sheds and pallets	800,000	4,400	.....	10 \$1 50	6

KOSCIUSKO COUNTY.

T. H. Wheeler.....	Warsaw	\$12,000	— soft mud brick machine	Sheds and pallets	1,000,000	\$6,000	.....	15 \$1 75	5
Phenel Bros	Nappanee.....	6,000	Freese tile machine.....	Sheds and pallets.....	100,000	600	\$3,600	7 \$1 25	7
Thacker Bros.....	Silver Lake.....	3,000	Potts tile machine.....	Sheds and pallets.....	.....	.....	2,510	3 \$1 35	6
M. W. Sellers.....	Packerton.....	2,000	Fate tile mill	Sheds and pallets.....	.....	.....	2,000	4 \$1 50	7

LAGRANGE COUNTY.

B. F. Ditman	Topeka.....	\$800	Edinburg brick machine....	Open yard.....	350,000	\$2,000	.....	5	\$1 50
Brillhart & Miller	Wolcottville	5,000	—soft mud and stiff mud machines.	Sheds and pallets.....	400,000	2,400	\$1,400	12	\$1 25

LAKE COUNTY.

Clark Manufacturing Co..	Lowell	\$5,000	Adrian brick and tile machine.	In sheds, by air	300,000	\$1,500	\$1,500	6	\$1 25
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LAPORTE COUNTY.

Roeske Bros	Michigan City	\$25,000	Cramer soft mud brick machine.	Sheds and pallets	5,300,000	\$31,900	45	\$1 60
Jno. P. Van Kirk	Laporte	8,500	—soft mud brick machine	Sheds and pallets	2,000,000	12,000	.....	18	\$1 85

LAWRENCE COUNTY.

Heitger & Winterhault.	Bedford	\$2,000	Cresager brick machine.....	Sheds and pallets,....	500,000	\$3,000	7	\$1 55
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MADISON COUNTY.

National Drain Tile Co...	Summitville.....	\$31,456	Two Taplin & Rice sewer pipe presses, two Madden tile machines.	Sewer pipe floors, by steam.	\$87,708	75	\$1 70
Orestes Tile Works.....	Orestes.....	10,000	Wallace tile machine, Rushville tile machine.	Sewer pipe floors, by steam.	.....	.....	16,000	11	\$1 90
Indiana Brick Co.....	Anderson	120,000	One Potts and one Hercules machines.	Standard tunnel dryer, by steam.	22,000,000	\$123,000	.....	100	\$2 20
Cooper Bros.....	Anderson	500	By hand.....	Open yard.....	200,000	1,500	.....	3	\$1 75

Statistics of Ordinary Building Brick and Drain Tile Industry—Continued.

MARION COUNTY.

NAME OF FIRM OR INDIVIDUAL.	Location.	Capital Invested	How Moulded.	How Dried.	Output of Brick in 1904.	Value of Brick.	Value of Tile.	No. of Hands and Daily Wage.	No. of Months Worked.
Frederick Bremer.....	Sherman Drive, In- dianapolis.	\$4,000	By hand.....	Open yard.....	800,000	\$6,000	.....	\$1 85 8	7
Cook & Schmidt.....	Beecher Street, In- dianapolis.	2,000	By hand.....	Sheds and pallets.....	350,000	2,000	.....	\$1 85 6	5
Herman Ellering.....	Bethel Avenue, In- dianapolis.	1,000	By hand.....	Open yard.....	600,000	4,500	.....	\$1 65 6	5
Herman Luedeman.....	Southeastern Ave- nue, Indianapolis.	9,000	By hand.....	Sheds and pallets.....	1,000,000	6,500	.....	\$1 90 8	6
Jas. Magennis.....	Sherman Drive, In- dianapolis.	2,000	By hand.....	Open yard.....	700,000	4,550	.....	\$1 75 7	7
Leonard Neuenburg.....	East 10th Street, In- dianapolis.	3,000	By hand.....	Sheds and pallets.....	700,000	3,500	.....	\$1 85 6	6
Chas. C. Quack.....	Norwood, Indiana- polis.	700	By hand.....	Sheds and pallets.....	700,000	4,500	.....	\$1 85 10	7
T. B. Laycock Mfg. Co.....	Indianapolis.....	6,000	.....	Sheds and pallets.....	1,500,000	9,000	.....	\$1 85 30	41
John Hohn.....	N. Indianapolis.....	5,000	By hand.....	Sheds and pallets.....	1,300,000	7,800	.....	\$1 75 13	8

MARSHALL COUNTY.

J. W. Thomas & Son.....	Six miles north of Plymouth.	\$10,000	Brewer brick and tile m ² chine.	50,000	\$300	\$3,700	9 \$1 25
Lement & Co.....	Teegarden	2,500	Sheds and pallets	200,000	1,200	2,300	5 \$1 30
Sarber & Sarber	Argos	4,000	Sheds and pallets	.....	.....	4,000	6 \$1 25

MARTIN COUNTY.

Layhead Bros. Brick and Tile Co.	Loogootes.....	\$8,000	Quaker brick machine.....	Sheds and pallets	1,000,000	\$5,500	.....	20 \$1 30	7
Moran Bros.....	Loogootes.....	6,500	Quaker brick machine.....	Sheds and pallets	1,000,000	5,750	.....	20 \$1 40	7

MIAMI COUNTY.

Ridgeway & Lamb.....	Amboy.....	\$5,000	New Departure tile machine.	Dry sheds, by steam.....	.....	\$2,400	8 \$1 40
Brubaker & Kreider.....	Perryburg.....	7,000	American brick and tile machine.	Dry sheds, by steam.....	.....	4,500	8 \$1 25

MONROE COUNTY.

	1	2	3	4
Dolan Brick and Tile Co.	Dolan	\$1,000	Brewer auger machine.....	Sheds and pallets
				75,000
				\$450
				\$1,100
				\$150

Statistics of Ordinary Building Brick and Drain Tile Industry—Continued.

MONTGOMERY COUNTY.

NAME OF FIRM OR INDIVIDUAL.	Location.	Capital Invested.	How Moulded.	How Dried.	Output of Brick in 1904.	Value of Brick.	Value of Tile.	No. of Hands and Daily Wage.	No. of Months Worked.
Everson & Ferguson	Crawfordsville	\$21,000	Hercules brick machine	Sharer hot air dryer	1,800,000	\$10,800	.....	15 \$1.75	9
F. J. Booker	New Ross	4,000	Fate auger tile machine	Sheds and pallets .....	.....	.....	\$3,000	4 \$1.50	4
Armantrout & Childers	New Market	2,500	Brewer tile machine	Sheds and pallets .....	.....	.....	2,700	8 \$1.75	6
H. K. Lee	New Richmond	10,000	Brewer tile machine	Sheds, by air and steam .....	.....	.....	10,000	15 \$1.60	8
T. J. Casey	Crawfordsville .....	.....	By hand	Sheds and pallets	600,000	3,600	.....	8 \$1.50	7
Wm. Hawkins	Crawfordsville	3,000	Quaker brick machine	Sheds and pallets	700,000	3,800	.....	14 \$1.50	5
Robert Robbins	Ladoga .....	.....	By hand .....	.....	200,000	1,400	.....	.....	.....
Kirk Bros.	Bowers Station	2,000	.....	Sheds and pallets .....	.....	.....	1,800	5 \$1.50	5

Statistics of Ordinary Building Brick and Drain Tile Industry—Continued.

PERRY COUNTY.

NAME OF FIRM OR INDIVIDUAL.	Location.	Capital Invested.	How Moulded.	How Dried.	Output of Brick in 1904.	Value of Brick.	Value of Tile.	No. of Hands and Daily Wage.	No. of Months Worked.
Geo. Diekman	Tell City	\$500	By hand	Sheds and pallets	200,000	\$1,200	.....	3 \$1 25	4

PIKE COUNTY.

J. E. Schurz	Petersburg .....	.....	By hand	Open yard	165,000	\$650	.....	2 \$1 25	1
Jno. M. Smith	Petersburg	\$500	By hand	Open yard	20,000	120	.....	14 \$1 53	4
Frank D. Read	Petersburg	7,000	Potts' brick machine	Sheds and pallets	700,000	3,500	.....	4 \$1 20	3
P. M. Ferguson	Spurgeon	500	By hand	Sheds and pallets	160,000	720	.....	8 \$1 25	2
Dempsey & Son	Otwell	500	Quaker machine	Sheds and pallets	500,000	2,500	.....	5 \$1 60	2
Wm. Coldemeyer & Sons.	Stendal	1,500	By hand	Open yard	125,000	625	.....	

PORTER COUNTY.

Chicago Hydraulic Press Brick Co.....	Porter.....	\$10,000	Martin soft-mud machine.	Sheds and pallets.....	1,475,400	\$11,903	.....	.....	10
P. H. Anderson & Sons ..	Chesterton.....	5,000	One Monarch soft-mud, one Brewer stiff-mud brick machine.	Sheds and pallets.....	1,500,000	7,500	.....	.....	6
R. S. Kenny.....	Hebron.....	7,500	Brewer tile machine.....	Sheds, by air and steam	.....	.....	\$5,250	.....	8
Chas. F. Lembke & Co....	Valparaiso.....	5,500	Cresger soft-mud brick ma- chine.	Sheds and pallets.....	1,000,000	7,000	.....	.....	6
Coovert & Clevenger	Valparaiso.....	4,000	Ohio auger tile machine...	Sheds and pallets.....	.....	.....	2,800	.....	6

POSEY COUNTY.

Geo. B. Beal.....	New Harmony.....	.....	Eagle soft-mud machine...	Sheds and pallets	135,000	\$945	.....	.....	2
Henry Brinkman.....	Mt. Vernon	\$5,000	Leader tile machine.....	Sheds and pallets.....	.....	.....	\$3,500	.....	8
Industrial Brick Co.....	Mt. Vernon	6,000	Martin brick machine.....	Sheds and pallets.....	3,227,500	19,365	.....	.....	7
Redmond & Co.....	Cynthiana	6,000	Anderson brick mill, Adri- an tile machine.	Sheds and pallets.....	800,000	4,800	480	.....	8

PULASKI COUNTY.

W. K. Widup.....	Winamac	\$3,000	Freese brick and tile ma- chine.	Sheds and pallets.....	.....	.....	\$3,000	.....	6
Francesville Brick & Tile Co.	Francesville	10,500	Brick and tile machine....	Sheds and pallets.....	150,000	\$1,000	7,000	.....	6
Orin Severns.....	Francesville.....	4,000	One auger tile machine.....	Sheds, by air.....	.....	.....	3,000	.....	7

Statistics of Ordinary Building Brick and Drain Tile Industry—Continued.

PUTNAM COUNTY.

NAME OF FIRM OR INDIVIDUAL.	Location.	Capital Invested.	How Moulded.	How Dried.	Output of Brick in 1904.	Value of Brick.	Value of Tile.	No. of Hands and Daily Wage.	No. of Months Worked.
J. A. Rice & Son	Roschdale	\$800	By hand.....	Sheds and pallets.....	400,000	\$2,400	.....	6 \$1 50	5
David Knoll	Cloverdale	2,000	Madden tile mill.....	Sheds and pallets .....	.....	.....	\$1,500	7 \$1 25	6
Wm. C. Rohling	Greencastle	2,000	Quaker brick machine.....	Sheds and pallets.....	.....	.....	.....	5 \$1 50	2

RANDOLPH COUNTY.

Kelley-Sanders Brick Co.	Winchester	\$15,000	Monarch brick machine ...	Tunnel dryer, by steam	2,000,000	\$14,000	.....	22 \$1 65	8
B. H. Strahan	Six miles N. W. of Winchester.	1,500	Little Giant tile mill.....	Sheds and pallets .....	.....	.....	\$1,600	4 \$1 25	4
Geo. Ashley	Stone Station.....	3,000	Press brick and tile ma- chine.	Sheds and pallets .....	.....	.....	1,300	2 \$1 25	6

RUSH COUNTY.

Rushville Brick and Tile Works.	Rushville	\$5,500	— sager brick machine.	Sheds and pallets	80,000	\$560	\$2,140	3 \$1 75	8
W. M. Bainbridge.....	Rushville	2,000	By hand.....	Open yard.....	300,000	2,100	.....	8 \$2 00	5
Arbuckle & Son.....	Homer	16,000	Madden tile machine.....	Sheds, by steam .....	.....	.....	10,000	10 \$1 40	10

SCOTT COUNTY.

D. W. Wyman & Son	Scottsburg	\$5,000	— brick and tile machine.	Standard dryer, by steam.	400,000	\$2,400	\$800	7 \$1 00	6
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SHELBY COUNTY.

Thos. Brooks	Shelbyville	\$1,000	Sheds and pallets	\$700	2 \$1 00	6
Schoeleh Bros	Shelbyville	15,285	— soft mud machine	Sheds and pallets	2,000,000	\$12,000	22 \$1 50	6
A. C. Bowlby & Son	Shelbyville	2,000	Ohio tile machine	Sheds and pallets .....	.....	.....	1,000	8 \$1 25	3

SPENCER COUNTY.

F. J. Bocking	Mariah Hill	\$1,200	By hand	Sheds and pallets	180,000	\$800	.....	6 \$1 00	2
St. Meinrad Brick and Tile Co.	St. Meinrad	2,000	Madden brick and tile machine.	Sheds and pallets	132,000	660	\$850	8 \$1 00	7
M. F. Underhill	Rockport	6,000	Madden brick and tile machine.	Sheds and pallets	782,600	4,700	2,918	13 \$1 25	74
Palmer Drain Tile Co.	Lake	5,500	Kell's brick and tile machine.	Sheds and pallets .....	.....	.....	3,500	7 \$1 00	6

Statistics of Ordinary Building Brick and Drain Tile Industry—Continued.

ST. JOSEPH COUNTY.

NAME OF FIRM OR INDIVIDUAL.	Location.	Capital Invested.	How Moulded.	How Dried.	Output of Brick in 1904.	Value of Brick.	Value of Tile.	No. of Hands and Daily Wage.	No. of Months Worked.
Mochel Bros. & Weigel...	Woodland	\$10,000	Anderson tile machine and Quaker brick machine.	Sheds and pallets.....	200,000	\$1,200	\$8,800	8 \$1 50	6
South Bend Brick Co. No. 1.	South Bend.....	30,000	Raymond 999 brick machine	Raymond dryer, by direct heat.	4,846,000	80,000	.....	52 \$1 85	9
South Bend Brick Co. No. 2.	South Bend.....	10,000	Monarch brick machine....	Sheds and pallets.....	2,500,000	15,000	.....	33 \$1 65	6
Frank Fisher	South Bend.....	6,000	Heroules "Junior" brick machine.	Sheds and pallets.....	1,886,000	11,000	.....	14 \$1 90	6
F. E. Perkins	South Bend.....	5,000	Heroules brick machine....	Sheds and pallets.....	1,500,000	9,000	.....	12 \$1 75	54

STREUBEN COUNTY.

Chas. A. Bachelor	Angola.....	\$10,000	Anderson brick and tile ma- chine.	Sheds and pallets.....	400,000	\$2,400	\$3,600	9 \$1 60	6
Angola Brick and Tile Co.	Angola.....	6,800	— soft-mud brick ma- chine. Auger tile mill.	Sheds and pallets.....	250,000	1,500	4,500	12 \$1 50	6

SULLIVAN COUNTY.

Parroni & Heap	Farmersburg	\$1,500	By hand	Sheds and pallets.....	600,000	\$3,000	8 \$2 00
Jas. Abbott	Hymers	1,000	By hand	Open yard	250,000	1,750	7 \$2 00
Zibis Howe	Sullivan	6,000	Steam press.....	Sheds and pallets.....	1,500,000	10,000	30 \$1 90

TIPPECANOE COUNTY.

Jacob May & Sons, South 4th St. yard.	Lafayette	\$5,000	Anderson soft-mud brick machine.	Sheds and pallets	1,500,000	\$9,250	.....	25 \$1 68	6
Jacob May & Sons, South 9th St. yard.	Lafayette	5,000	Wallace brick and tile machine.	Dry sheds, by steam; sheds and pallets.	1,000,000	5,500	\$3,600	14 \$1 66	8
Henry Kneale	Montmorenci	2,000	Wonder tile mill	Sheds, by air .....	.....	.....	1,900	6 \$1 35	6
Union Brick Co.	Lafayette	5,000	.....	Sheds, by steam	600,000	3,000	.....	11 \$1 75	3

TIPTON COUNTY.

P. P. Parnell.....	Goldsmith & Hobbs.....	\$20,000	Taplin-Rice tile press, Freeze New Departure tile machine.	Dry floors, by steam.....	\$80,000	30 \$1 50	11
Edw. Henry.....	Tipton.....	9,000	.....	Sheds and pallets.....	\$10,500	13 \$1 60	6
Tipton Clay Co.....	Tipton.....	18,000	— soft mud brick ma- chine.	Sheds and pallets.....	6,000	14 \$1 50	7
Continental Tile & Brick Co.....	Curtisville.....	20,000	Taplin-Rice tile press and — tile machine.	Dry floors, by steam.....	22,175 \$1 35	25	10
Thos. F. Lindsey.....	Kempton.....	7,000	— tile press and — tile machine.	Dry floors, by steam.....	5,000	9 \$1 34	8
Windfall Manfg. Co.....	Windfall.....	25,000	Sewer-pipe press.....	Dry floors, with gas.....	10,000	18 \$1 60	10

Statistics of Ordinary Building Brick and Drain Tile Industry—Continued.

VANDERBURGH COUNTY.

NAME OF FIRM OR INDIVIDUAL.	Location.	Capital Invested.	How Moulded.	How Dried.	Output of Brick in 1904.	Value of Brick.	Value of Tile.	No. of Hands and Daily Wage.	No. of Months Worked.
Henry Alexander.....	Evansville.....	\$7,000	By hand.....	Sheds and pallets.....	400,000	\$2,000	.....	7 \$1 55	3
Samuel Wellmeier.....	Evansville.....	7,000	By hand.....	Open yard.....	600,000	3,000	.....	6 \$1 65	6
Standard Brick Co.....	Evansville.....	8,000	Creager soft mud machine.	Sheds and pallets.....	3,666,000	18,350	.....	33 \$1 65	7
First Avenue Brick and Tile Co.	Evansville.....	15,000	Potts soft mud machine....	Sheds and pallets.....	3,300,000	16,500	\$360	35 \$1 65	7
Sophie Heseman.....	Evansville.....	5,000	By hand.....	Open yard.....	500,000	3,000	.....	6 \$1 50	5
Jno. Waterman.....	Evansville.....	2,000	By hand.....	Sheds and pallets.....	800,000	4,200	.....	8 \$1 65	7
Klamer Bros.....	Evansville.....	1,500	By hand.....	Open yard.....	450,000	2,365	.....	7 \$1 50	7
John Herdink.....	Evansville.....	2,000	By hand.....	Sheds and pallets.....	750,000	3,950	.....	8 \$1 75	7
Ernest Wedeking.....	Evansville.....	5,000	Creager soft mud machine.	Sheds and pallets.....	1,600,000	8,400	.....	20 \$1 50	7

VERMILLION COUNTY.

National Drain Tile Co.....	Hillsdale.....	\$32,452	Taplin-Rice sewer-pipe press, Madden tile machine.	Dry floors, by steam.....	.....	\$104,384	75 \$1 70	12
Cayuga Brick & Coal Co.....	Cayuga.....	110,000	American stiff mud brick machine.	In tunnels, by steam and waste heat.	6,576,000	\$44,405	70 \$1 90	8
Acme Brick Works.....	Cayuga.....	20,000	Wallace brick machine....	In tunnels, by direct heat.	2,000,000	10,000	55 \$1 75	7
Newport Brick & Clay Co.....	Newport.....	20,000	Little Wonder brick and tile machine.	On hot floor, by steam.	1,250,000	6,250	30 \$1 75	5
Wm. Martin & Son.....	Rileysburg.....	2,000	.....	Sheds and pallets.....	.....	.....	5 \$1 25	6
Eureka Brick Co.....	Clinton.....	6,000	Monarch brick machine....	Sheds and pallets.....	700,000	3,500	10 \$1 60	5

VIGO COUNTY.

National Drain Tile Co.	Terre Haute	\$35,280	Taplin-Rice press, Madden tile machine.	Dry floors, by steam	.....	\$102,531	70 \$1 70	12
C. M. Miller Mining and Manufacturing Co.	Terre Haute	25,000	Wallace stiff mud brick machine.	Sheds and pallets	800,000	\$1,000	15 \$1 75	4
C. W. Hoff Brick Co.	Terre Haute	16,000	Monarch soft mud brick machine.	Sheds and pallets	3,250,000	19,500	27 \$2 00	64
Chas. Smith	Terre Haute	500	By hand	Open yard	200,000	1,200	8 \$2 00	4
Co-operative Brick Co.	Terre Haute	3,000	By hand	Open yard	1,850,000	11,100	15 \$2 00	6
O'Mara Bros.	Terre Haute	5,000	By hand	Open yard	1,900,000	11,400	17 \$2 00	64
W. Bergemann	Terre Haute	7,000	By hand	Open yard	1,800,000	\$10,800	16 \$2 00	64
Terre Haute Pressed Brick Co.	Terre Haute	10,000	Potts soft-mud machine	Sheds and pallets	2,500,000	15,000	23 \$2 00	64
J. J. Bennett & Sons.	Terre Haute	8,000	By hand	Open yard	1,800,000	10,800	17 \$2 00	64

Statistics of Ordinary Building Brick and Drain Tile Industry—Continued.

WABASH COUNTY.

NAME OF FIRM OR INDIVIDUAL.	Location.	Capital Invested.	How Moulded.	How Dried.	Output of Brick in 1904.	Value of Brick.	Value of Tile.	No. of Hands and Daily Wage.	No. of Months Worked.
Edward Haggerty	Lafontaine	\$1,500	Quaker brick machine	Sheds and pallets	275,000	\$1,550	.....	\$1 40	44
M. Giek	N. Manchester	4,000	Penfeld stiff-mud machine.	Sheds and pallets	850,000	5,280	.....	\$1 79	5
Ernest H. Carothers	7 miles N. W. of Wabash.	500	Chandler & Taylor tile machine.	Sheds, by air .....	.....	.....	\$500	\$1 25	3
Albert Shinkel	Wabash	1,500	Potts brick machine	Sheds and pallets	150,000	1,000	.....	\$1 50	2

WARREN COUNTY.

Alex. Hamar	West Lebanon	\$10,000	McKenzie tile machine	Sheds, by air	\$6,000	\$1 40	8
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WARRICK COUNTY.

Warrick Roofing Tile Co.	Newburgh	\$18,000	Raymond stiff-mud brick machine.	Sheds and pallets	325,000	\$1,800	6	8
Star Brick and Clay Co.	Newburgh	8,000	Adrian brick and tile machine.	Dry floors and sheds by air.	200,000	1,200	.....	10	6
Louis Klotzmeier	Boonville	10,000	— brick and tile machine.	Dry floor by steam, sheds and pallets.	1,200,000	6,000	\$1,600	12	7
Industrial Brick Works..	Boonville	10,000	— soft-mud brick machine.	Sheds and pallets	600,000	3,000	.....	14	3
Jarvis & Thene	Elberfeld	4,000	By hand	Sheds and pallets	200,000	4,440	.....	6	2
John Sertel	Lynnville	2,000	By hand	Open yard	200,000	1,100	.....	6	3
								\$1 28	

WASHINGTON COUNTY.

Kern Shrum	Salem	\$4,750	— soft-mud machine	Sheds and pallets	800,000	\$5,500	.....	.....	6
Franklin Bros	Little York	1,500	Freese tile mill	Sheds and pallets .....	.....	.....	\$2,000	4	1
								\$1 00	

WAYNE COUNTY.

Chas. H. Meyer	Richmond	\$4,500	.....	Sheds, by air .....	.....	.....	\$3,000	6	6
Philip Fransman	East Germantown...	4,000	Ohio tile mill	Sheds, by air .....	.....	.....	1,828	8	4
W. C. Thistlethwaite	Richmond	4,000	Potts soft-mud machine	Sheds and pallets	3,000,000	\$21,000	.....	33	7
								\$2 00	

Statistics of Ordinary Building Brick and Drain Tile Industry—Continued.

WELLS COUNTY.

NAME OF FIRM OR INDIVIDUAL.	Location.	Capital Invested.	How Moulded.	How Dried.	Output of Brick in 1904.	Value of Brick.	Value of Tile.	No. of Hands and Daily Wage.	No. of Months Worked.
O. J. Montgomery	Bluffton	\$3,000	— auger tile machine	Sheds, by air .....	.....	.....	\$2,500	\$1 50	5
Buckner & Irwin	Bluffton	1,400	— soft-mud brick machine	Sheds and pallets	600,000	\$3,900	.....	13	4½
J. W. Cook	Poneto	4,500	Madden tile machine	Sheds, by air .....	.....	.....	3,000	12 \$1 13	5
Beaty & Doan	Ossian	3,550	— soft-mud brick machine	Sheds and pallets	500,000	3,000	.....	8 \$1 50	5
J. C. Bell	Craigville	3,000	Freese brick and tile mill	Sheds, by air .....	.....	.....	3,000	5 \$1 50	6

WHITE COUNTY.

J. T. Cuppy	Chalmers	\$8,000	Brewer tile machine	Dry floors, by steam .....	.....	.....	\$8,400	10 \$1 60	8
Michael Pine	Idaville	3,200	Brewer tile machine	Dry floors, by steam .....	.....	.....	2,200	5 \$1 50	7
Hussey & Alford	Monon	2,000	Ohio Boy auger mill	Sheds and pallets .....	.....	.....	2,500	6 \$1 35	5

VII. THE PRODUCTION OF CLAY FOR SHIPMENT.

Raw clay is produced and shipped from a number of points in Indiana. At some places it is in part ground before shipping; at others it is loaded directly from the mine or pit into the car.

Within the past five years three factories have been erected in Vermillion County to prepare by grinding for shipment the under-clay No. 10, found beneath coal VIb in the area between Hillsdale and Newport. At the plant of the Hoosier Clay Works, a mile and a quarter west of Hillsdale, the under-clay is dumped from tram cars by the side of a 9-foot dry pan. After grinding the clay is elevated and passes over a gravity four-foot "piano screen." This furnishes a coarse-grained product. If one of finer grain is desired, the clay is passed over an eight-foot 1-6-inch perforated steel screen. One hundred tons of the coarse or 70 tons of the finer can be ground and screened in ten hours, or an average carload in three and a half hours. Three hands are employed, viz., engineer, pan feeder and car loader, the ground clay passing through chutes leading from a large storage bin below the screens to the cars on sidetracks. Three men are employed in the mine, the clay being delivered at the plant for 45 cents per ton.

At the Wabash Valley Clay Works, one-half mile south of West Montezuma, but one grade of clay is produced, a 9-foot Wooley dry pan and 10-foot gravity screen being used. No storage bin is in the plant, the clay being ground only as orders are received, and passing from the screen directly into the car. The clay costs about 40 cents per ton at the plant, and the expense of grinding is 15 cents.

The D. N. Lanyon plant, located three-quarters of a mile north of West Montezuma, is equipped with a 9-foot dry pan and 18-foot gravity screen and a storage bin holding 15 carloads of ground clay.

In addition to these plants, which have been erected for the special purpose of grinding clay for the market, the larger manufacturing plants of the Burns & Hancock Fire Brick Co. and the Southern Fire Brick & Clay Co. also grind and ship large quantities of the under-clay No. 10.

The following table comprises the statistics of the production of clay in Indiana for 1904. In compiling these figures, only the clay sold by the producer has been considered, that manufactured by the producer not being taken into account:

Statistics of the Raw and Ground Clay Industry in Indiana for the Year 1904.

NAME OF PRODUCER.	Location.	Kind of Clay.	Raw Clay. No. of Tons.	Value.	Prepared Clay. No. of Tons.	Value.
Burns & Hancock Fire Brick Co.	W. Montezuma, Vermillion County.	Under-clay No. 10 ...	.....	.....	2,000	\$2,500
Southern Fire Brick and Clay Co.	W. Montezuma, Vermillion County.	Under-clay No. 10 ...	.....	.....	5,728	5,728
Hoosier Clay Works.	Hillsdale, Vermillion County	Under-clay No. 10 ...	.....	.....	4,500	4,500
Wabash Valley Clay Co.	Hillsdale, Vermillion County	Under-clay No. 10 ...	3,060	\$918	1,570	1,918
D. N. Lanyon	Hillsdale, Vermillion County	Under-clay No. 10 ..	.....	.....	6,000	4,800
Boeking Bros....	Huntingburg, Dubois County	Plastic potters' clay, for stoneware.	2,800	2,800	.....	.....
Huntingburg Pressed Brick Co	Huntingburg, Dubois County	Plastic potters' clay, for stoneware.	4,380	5,575	.....	.....
Pyrsh Coal and Clay Co.	Brazil, Clay County.	Plastic under-clay, for stoneware, encaustic tile, etc.	2,610	2,610	.....	.....
Benj. Simpson	Carbon, Clay County.	Under-clay beneath No. III Coal.	1,500	2,100	500	750
J. V. Ayer	Brazil, Clay County.	Under-clay beneath No. IV Coal.	3,705	2,779	.....	.....
John C. Boss	Elkhart, Elkhart County.	Slip clay, for glazing stoneware.	250	250	.....	.....
Brazil Block Coal Co.	Saline City, Clay County.	Plastic under-clay, for enameled brick and tile.	4,985	4,985	.....	.....
Zack Messick	Freedom, Owen County.	Pinkish plastic clay, for encaustic tile.	200	250	.....	.....
Total .....	.....	.....	28,490	\$22,267	20,296	\$20,189



REPORT OF STATE INSPECTOR OF MINES.

OFFICE OF INSPECTOR OF MINES,
INDIANAPOLIS, INDIANA, March 4, 1905.

Prof. W. S. Blatchley, State Geologist:

DEAR SIR: I have the honor to submit to you herewith my sixth annual report as Inspector of Mines, covering the calendar year of 1904, and being the Twenty-sixth Annual Report of this Department and the fourteenth made to the Department of Geology and Natural Resources.

I trust it will receive your approval and be found worthy of consideration by the public.

JAMES EPPERSON,
Inspector of Mines.

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ANNUAL REPORT.

STATISTICS OF COAL AND GENERAL INFORMATION PERTAINING TO THE MINES OF INDIANA FOR THE YEAR ENDING DECEMBER 31, 1904.

This report includes, or covers, the following subjects or topics arranged in the order enumerated: Conditions of Coal Trade, Labor Conditions, Mine Accidents and Statistics. Under Conditions of Coal Trade a general review of the coal business for the past year is given as fully as possible. Under the head of Labor Conditions we include strikes that have occurred, Terre Haute and Brazil Agreements and other conditions relating to labor. Under Mine Accidents various tables are given exhibiting the cause, number and frequency of accidents to mine employes; also, accidents to mine property. Under the statistical part of the report numerous tables are presented showing the production of the different kinds and grades of coal, amount of wages paid to employes, the number of persons employed in the different capacities, number of mules used, number of mining machines, tables of averages, comparative tables, directory of mines and a table showing the geological number of coal seam mined and character of roof and floor at each mine in the State.

In the following summary will be found most of the important totals for the State for the year:

Number of counties having shipping mines.....	14
Number of coal companies operating mines.....	137
Number of mines working more than ten men.....	210
Number of new coal companies organized.....	23
Number of new mines opened.....	42
Number of mines abandoned	10
Number of pick miners employed.....	8,806
Number of machine runners	380
Number of machine helpers	380
Number of loaders	3,046
Number of inside day and monthly men employed.....	3,449
Number of outside day and monthly men employed.....	1,777

Number of mules used	1,421
Number of electric chain machines.....	291
Number of compressed air punching machines.....	104
Total number of mining machines.....	395
Number of electric motors	30
Number of dynamos	67
Number of compressors	28
Total number days mines have been operated.....	29,641
Total tons of hand-mined block coal.....	640,567
Total tons machine-mined block coal.....	86,505
Total tons block coal	727,072
Total tons bituminous hand-mined coal	5,645,663
Total tons bituminous machine-mined coal	3,499,069
Total tons bituminous coal produced	9,145,332
Total tons hand-mined coal produced	6,286,230
Total tons machine-mined coal produced	3,586,174
Total tons of coal produced	9,872,404
Total tons of coal consumed in Indiana.....	5,304,906
Total tons of coal shipped outside of the State.....	4,567,898
Amount of wages paid to miners	\$5,865,063 63
Amount of wages paid to outside day and monthly men....	1,146,871 64
Amount of wages paid to inside day and monthly men....	2,153,499 11
Total amount of wages paid to all employes.....	9,165,404 64
Amount of money spent on improvements.....	74,230 85
Total number of fatalities	34
Total number of serious accidents.....	132
Total number of minor accidents	81
Total number of accidents to employes	247
Total number of accidents to mine property	12

TABLE

Showing by Months and by Counties the Number of Tons Mined and Wages Paid to Employes for the Year 1904 at Mines Employing More Than Ten Men.

MONTH.	CLAY COUNTY.		DAVISS COUNTY.	
	Tonnage.	Wages.	Tonnage.	Wages.
January	104,907	\$132,870 31	16,571	\$17,219 75
February	108,216	126,532 89	17,966	18,934 77
March	106,758	120,422 21	16,596	18,441 37
April	52,917	64,912 26	12,694	13,937 42
May	45,839	58,474 10	8,083	10,559 79
June	47,761	65,653 30	8,004	9,224 32
July	58,563	72,955 20	6,289	7,282 67
August	75,311	103,159 60	9,076	10,115 20
September	73,606	96,997 53	9,004	9,366 90
October	80,798	96,979 96	9,786	10,213 49
November	85,406	99,323 42	10,201	11,113 98
December	89,966	106,708 06	10,601	10,068 46
Total	20,043	\$1,142,523 33	133,270	\$146,498 49

MONTH.	FOUNTAIN COUNTY.		GIBSON COUNTY.	
	Tonnage.	Wages.	Tonnage.	Wages.
January	4,335	\$5,406 02	8,567	\$8,819 99
February	4,663	5,447 31	8,302	8,306 31
March	3,223	3,841 27	9,406	11,677 91
April	2,506	2,898 66	3,611	5,626 15
May	4,329	4,307 17	2,596	3,427 45
June	5,050	5,163 78	2,509	3,874 21
July	3,584	4,020 36	4,894	5,229 07
August	6,154	6,238 52	6,251	6,345 64
September	5,677	5,989 87	7,080	7,101 08
October	5,785	6,150 09	9,871	9,672 99
November	4,935	5,474 29	10,392	9,463 03
December	5,669	5,654 98	11,937	10,539 41
Total	55,910	\$60,392 32	85,596	\$90,082 24

MONTH.	GREENE COUNTY.		KNOX COUNTY.	
	Tonnage.	Wages.	Tonnage.	Wages.
January	222,487	\$197,602 37	15,423	\$14,875 84
February	237,798	203,292 05	16,993	13,828 69
March	249,538	209,745 93	17,715	14,973 06
April	127,737	114,415 75	8,964	8,084 49
May	134,897	123,378 63	6,596	6,034 55
June	148,185	136,901 16	6,106	6,127 30
July	142,964	127,684 63	6,032	5,817 34
August	172,028	150,305 82	7,250	6,849 21
September	179,531	158,535 16	12,932	9,897 53
October	201,526	176,976 64	15,040	13,521 90
November	243,257	192,360 79	17,998	15,005 26
December	248,066	193,106 07	19,528	17,367 75
Total	2,307,964	\$1,984,305 00	150,567	\$132,132 80

MONTH.	PARKE COUNTY.		PERRY COUNTY.	
	Tonnage.	Wages.	Tonnage.	Wages.
January	89,378	\$111,191 83	206	\$312 76
February	90,881	109,821 64	269	414 63
March	85,605	103,779 41	1,217	1,273 58
April	41,890	57,410 68	1,268	1,153 64
May	33,833	45,503 05	705	815 49
June	48,696	58,724 04	735	762 94
July	56,039	72,157 14	753	793 71
August	80,281	100,041 00	854	819 78
September	77,339	93,397 17	566	607 20
October	74,594	75,500 98	204	291 79
November	81,797	80,569 91	235	361 89
December	82,944	82,220 69	263	352 50
Total	813,377	\$993,317 04	7,275	\$7,959 41

MONTH.	PIKE COUNTY.		SULLIVAN COUNTY.	
	Tonnage.	Wages.	Tonnage.	Wages.
January	\$7,681	\$33,896 09	124,086	\$124,580 87
February	40,127	35,091 77	128,765	120,135 13
March	37,770	32,657 25	122,629	114,904 07
April	26,772	17,956 19	87,717	84,676 99
May	23,773	16,114 83	86,855	80,270 53
June	16,633	15,968 89	92,116	86,293 15
July	7,558	4,242 16	166,189	95,545 04
August	29,600	21,526 05	138,270	126,575 94
September	36,247	26,158 07	145,026	135,059 76
October	36,682	32,993 20	167,372	138,219 22
November	43,312	35,295 06	192,034	156,571 95
December	42,956	26,208 87	205,539	174,903 74
Total	349,133	\$298,108 23	1,589,974	\$1,437,746 39

MONTH.	VANDERBURGH COUNTY.		VERMILLION COUNTY.	
	Tonnage.	Wages.	Tonnage.	Wages.
January	22,972	\$23,345 17	89,782	\$76,470 09
February	24,640	24,983 24	99,033	80,363 63
March	18,533	18,527 48	120,724	90,845 90
April	14,252	14,590 43	48,262	37,144 65
May	9,542	10,230 47	82,471	68,324 61
June	7,646	10,458 99	89,169	73,043 92
July	10,179	10,242 27	74,469	72,035 62
August	15,012	20,536 99	82,951	70,471 59
September	20,226	25,813 64	95,829	94,692 13
October	29,745	27,820 03	102,229	84,640 90
November	27,703	24,699 95	119,265	96,210 46
December	27,175	23,761 62	117,566	86,805 86
Total	237,625	\$234,911 18	1,131,750	\$931,049 25

MONTH.	VIGO COUNTY.		WARRICK COUNTY.	
	Tonnage.	Wages.	Tonnage.	Wages.
January	147,039	\$136,986 67	33,140	\$20,688 50
February	160,376	144,866 67	31,404	19,794 41
March	173,749	148,753 82	37,316	22,167 90
April	100,488	83,087 32	20,796	15,396 35
May	113,303	103,127 63	19,867	12,463 96
June	108,443	92,927 70	21,690	13,661 06
July	115,020	108,516 61	23,280	14,016 40
August	152,554	124,473 21	25,889	16,113 07
September	139,754	126,103 34	26,696	16,292 01
October	154,109	133,727 48	37,355	18,577 85
November	171,755	148,139 43	27,214	19,027 19
December	182,431	142,450 52	37,253	22,219 34
Total	1,719,021	\$1,491,498 04	341,900	\$212,418 54

CONDITION OF COAL TRADE.

The coal business in general throughout the State for 1904 was not as profitable to the mine owner as it was the preceding five or six years. The selling price of coal has been very low, ranging from 90 cents to \$1.20 per ton of run coal at the mine, and a majority of the mines, especially during the spring and summer months, were operated less than half time. The total production, which reached 9,872,404 tons in 1903, shows a decrease of 120,149 tons, or a fraction over 1 per cent. under 1903. This was a very small decrease in production, and to those not conversant with the situation it would not seem to should not distress the business to any considerable extent. Considering the fact that forty-two new mines have been put into operation during the year, which have helped to furnish the increased production, it can be readily understood why the mines have been operated so steadily and why prices have been so low. The large increase in the number of new mines and the increased demand for cars and transportation facilities, thereby being more than the railroads could meet, was responsible for the depressed condition of the business. The aggregate wages paid in 1904 was \$9,165,404.38, an increase over 1903 of \$15,832.26, or a fraction over 1-10 of 1 per cent. The fact that this report shows a decrease in production and an increase in expenditure may seem strange. The following figures, however, will explain the situation thoroughly, viz.: The fixed operating expense at each mine, whether the mine was in operation or not, and where a mine has been operated but less than ten days during the month there is a large balance to carry over for operating expense for the days the mine has been in operation. Another reason for the increase in expenditures was the fact that a majority of the new companies have reported as wages the amount of money paid to employees during the time of developing the property and before the mine had reached a producing condition, which is worth mentioning.

The total number of employees for 1904 was 17,838, an increase of 2,710 employees over 1903, and the average wage to the miner, the average earnings to be \$465.03 per miner, \$624.38

day and monthly men and \$645.96 per outside day and monthly men. Considering the number of days the mines were idle and time lost from other causes the above figures speak very favorable for the earning capacity of persons employed at Indiana mines.

NEW DEVELOPMENT.

The year 1904 marks the greatest period in the development of mining properties in the history of the State. During that period twenty-three new coal companies were organized and forty-two new mines opened and developed, which are distributed in the different counties as follows:

Clay County, five new coal companies and fourteen new mines, nine block and five bituminous; Greene County, two new companies and three new mines; Gibson County, one new company and one new mine; Knox County, two new companies and two new mines; Parke County, two new mines; Perry County, one new company and one new mine; Sullivan County, seven new companies and eleven new mines; Vermillion County, one new company and two new mines; Vigo County, three new companies and five new mines; Warrick County, one new company and one new mine.

In addition to the new mines opened, three of the older ones, viz., the Keystone, at Shelburn; Hymera No. 1 and the Island Valley No. 2, have been sunk to seams at a lower depth. As shown by the table of new mines, twenty-two are hand, or pick, mines; twenty electric chain machine mines, and three compressed air punching machine mines, the greater number of which, especially those in the bituminous field, have been equipped with the latest improved machinery of all kinds, such as box car loaders, shaker screens, self-dumping cages, etc., and should approximately increase the coal-producing capacity of the State at least 20 per cent.

We submit herewith a table exhibiting, by counties, the names of the companies operating these new mines, the names of the mines, the railroad on which they are located, the geological number and thickness of coal seams, by feet and inches; size and depth of shaft, kind of machines used, when mines were opened and when first shipment of coal was made.

TABLE OF NEW MINES.

BLOCK COAL MINES.

CLAY COUNTY.

NAME OF COMPANY.	NAME OF MINE.	RAILROADS.	Geological Num- ber of Seam.	Thickness of Seam.	Depth of Shaft.	Size of Shaft.	Machine or Pick Mine.	Kind of Machine.	Date of Develop- ment.	First Shipment.
Zellar, McClellan & Co.....	Superior No. 4.....	S. Branch Vandalia	IV	3-8	90	8x21	Pick.....	.....	1-20,'04	9-20,'04
Brazil Block Coal Co.....	Brazil Block No. 4.....	C. & E. I.....	III	4-0	160	8x17	Machine..	.....	8-1,1900	9-20,'04
Crawford Coal Co.....	Crawford No. 2.....	S. Branch Vandalia	IV	3-3	68	8x20	Pick.....	.....	8-8,'04	.....
Crawford Coal Co.....	Crawford No. 4.....	S. Branch Vandalia	IV	3-6	80	7x16	Pick.....	.....	7-20,'04	11-25,'04
Crawford Coal Co.....	Crawford No. 8.....	S. Branch Vandalia	IV	4-0	50	8x20	Pick.....	.....	7-7,'03	11-25,'04
Crawford Coal Co.....	Crawford No. 9.....	C. & E. I.....	IV	3-9	86	7x18	Pick.....	.....	6-1,'03	11-4,'04
Dan Davis Coal Co.....	Dan Davis.....	S. Branch Vandalia	IV	3-6	57	8x20	Pick.....	.....	5-1,'01	8-1,'04
Lower Block.....	Lower Block.....	T. H. & F.....	IV	3-9	48	8x16	Pick.....	.....	11-15,'03	1-1,'04
Indiana Block Coal Co.....	Indiana Block.....	E. & I.....	IV	3-0	58	8x20	Pick.....	.....	9-1,'03	1-1,'04

VIGO COUNTY.

Domestic Block Coal Co.....	Domestic Block.....	C. & E. I.....	IV	4-0	108	8x15	Pick.....
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TABLE OF NEW MINES—Continued

BITUMINOUS MINES.

CLAY COUNTY.

NAME OF COMPANY.	NAME OF MINE.	RAILROADS.	Geological Num- ber of seam.	Thickness of Seam.	Depth of Shaft.	Size of Shaft.	Machine or Pick Mine.	Kind of Machine.	Date of Develop- ment.	First Shipment.
Jasonville Coal Co.	Gold Knob.	S. I.	III	6-8	203	8-6x16	Machine.	Elec. chain.	9-10, '03	7-2, '04
Vivian Coal Co.	Vivian No. 4.	S. I.	III	5-6	107	9x15	Machine.	Elec. chain.	5-15, '03	12-1, '04
Vivian Coal Co.	Vivian No. 5.	S. I.	IV	5-6	43	9x15	Machine.	Elec. chain.	7-15, '03	12-1, '04
Island Valley Coal Co.	Island Valley No. 4.	S. I.	IV	4-10	104	8x16	Machine.	Elec. chain.	5-1, '03	12-1, '04
Coal Bluff Mining Co.	Glen No. 2.	C. & E. I.	IV	4-0	85	8x16	Pick.	.....	10-1, '03	7-23, '04

GREENE COUNTY.

Pennsylvania Ind. C. Co.	Pennsylvania.	S. I.	III	7-6	217	9x16	Pick.	.....	1903	7-10, '04
Coal Bluff Mining Co.	Twin.	I. & V.	IV	.....	152	9x30	Pick.	Elec. chain.	11-5, '02	1903
North Linton Coal Co.	North Linton	S. I.	IV	4-2	68	9x14	Pick.	.....	8-1, '03	Jan., '04
Island Valley Coal Co.	Island Valley No. 2.	I. & V.	V	7-6	.....	.....	Machine.	Comp. air puncher.	.....	.....

GIBSON COUNTY.

Fort Branch Coal Co.	Fort Branch.	E. & T. H.	VI	5-0	232	9x17	Pick.	5-14, '04	12-1, '04
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KNOX COUNTY.

Enterprise Coal Co	Enterprise	I. & V	VI	4-3	154	11x7	Machine..	Comp. air puncher..	6-1, '03 5-16, '04	1-2, '04 11-12, '04
Big Muddy Coal Co	Big Muddy	I. & V	VI	4-6	210	8x16	Machine..	Elec. chain.		

PARKE COUNTY.

Mecca Coal Co	Mecca No. 4	C. & I. C.	III	6	...	8x19	Machine..	Elec. chain.	9-12, '03 7-2, '03	2-22, '04 2-28, '04
Mecca Coal Co	Mecca No. 3	C. & I. C.	III	5	166	9x18	Machine..	Elec. chain.		

PERRY COUNTY.

Lincoln Coal Co	Lincoln	Southern (Cannel- ton Branch)	II	3-4	Slope	Pick	See note
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SULLIVAN COUNTY.

Coal Bluff Mining Co	Shirley Hill	Monon	VI	5-6	110	9x16	Pick	Elec. chain.	9-0, '03	6-20, '04
New Pittsburgh Coal Co	Phoenix No. 4	E. & T. H.	VI	6-0	242	8-8x18-8	Machine	Elec. chain.	4-1, '04	11-15, '04
Keystone Coal Co	Shelburn	E. & T. H.	V	6-0	326	.....	Machine	Elec. chain.	See note	.....
Jackson Hill Coal Co	Jackson Hill No. 4	Branch E. & T. H., Farmersburg	VI	6-6	155	8x18	Pick .....	.....	11-19, '03	6-19, '04
Hymers Coal Co	Hymers No. 3	E. & T. H.	VI	5-0	237	8x24	Machine	Elec. chain.	.....	1-1, '04
Reliance Coal Co	Reliance	E. & T. H.	VI	5-3	152	7-4x16	Machine	Elec. chain.	5-18, '04	8-1, '04
Kettle Creek Coal Co	Kettle Creek	Farmersburg	VI	5-3	.....	.....	.....	.....	.....	.....
Linton Bituminous Coal Co	Hamilton	Branch E. & T. H. Farmersburg	III?	6-6	255	9x16	Machine	Comp. air puncher..	11-1, '03	10-0, '04
Linton Semi-Block Coal Co	Wolford	S. I.	III?	6-5	242	9x18	Machine	Elec. chain.	9-0, '03	9-0, '04
Keller Coal Co	Virginia	E. & T. H.	VI	6-0	200	9x18	Machine	Elec. chain.	11-10, '03	9-15, '03
Union Coal Co	Union	E. & T. H.	VI	5-6	235	9x19	Machine	Elec. chain.	9-0, '03	9-0, '04
Clover Leaf Coal Co	Clover Leaf	I. C.	IV	5-9	306	8x19	Machine	Elec. chain.	No coal shipped.	.....
Hymers Coal Co	Hymers No. 1	Branch E. & T. H., Farmersburg	III?	.....	.....	.....	Machine	Elec. chain.	.....	.....

TABLE OF NEW MINES—Continued.

BITUMINOUS MINES—Continued.

VERMILLION COUNTY.

NAME OF COMPANY.	NAME OF MINE.	RAILROADS.	Geological Num- ber of Seam.	Thickness of Seam.	Depth of Shaft.	Size of Shaft.	Machine or Pick Mine.	Kind of Machine.	Date of Develop- ment.	First Shipment.
Maple Valley Coal Co.	Maple Valley.	C. & E. I.	VI	6-6	149	8-6x17-6	Pick. ....	.....	9-15, '03	5-0, '04
McClellan, Sons & Co.	Buckeye No. 2.	C. & E. I.	VII	4-8	.....	8x20	Pick. ....	.....	5-20, '04	9-1, '04

VIGO COUNTY.

Vigo County Coal Co.	Ray No. 2.	Vandalla.	VI	7-4	95	8x20	Machine.	Comp. air puncher.	9-1, '03	1-14, '04
Miami Coal Co.	Miami No. 3.	C. & E. I.	VI	7-0	95	8x18	Pick. ....	.....	5-1, '04	9-10, '04
Forrest Park.	Forrest Park.	Big Four.	VI	6-5	150	8-8x20	Machine. ....	.....	5-8, '04	8-10, '04
Indiana Fuel Co.	Riverside.	C. & E. I.	VII	4-8	110	9x19	Pick. ....	.....	5-1, '04	6-9, '04

WARRICK COUNTY.

Chandler Coal Co.	Chandler.	Southern.	V	5	120	8x15	Pick.	5-15, '04	8-16, '04
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IMPROVEMENTS.

The monthly reports of coal companies made to this ing the year just ended show an aggregate of \$74,230.8 ing been expended on improvements of various kinds different mines. The following, while not representing amount of money expended, shows some of the most improvements made:

CLAY COUNTY.

The Brazil Block Coal Company installed a ten-foot fan, encased in steel, at their No. 8 Mine, which has improvement in the ventilation of that mine.

GREENE COUNTY.

The Island Coal Company have installed electric motor in their Island No. 1 Mine.

The L. T. Dickerson Coal Company have installed motor haulage in their Glenburn mine, and have also made changes in the arrangement of the shaft bottom, increasing the capacity of the mine, as well as reducing operating expense of handling the coal.

The Black Creek Coal Company have also installed motor haulage in their Black Creek Mine.

PIKE COUNTY.

The S. W. Little Coal Company have installed electric haulage in their S. W. Little Mine, and have made other improvements in and around the mine. Prior to the introduction of the motors this mine was using twenty-one mules producing 600 tons of coal per day. At the present time producing 800 tons per day and using eleven mules, which saves a large saving in operating expenses.

VANDERBURGH COUNTY.

The Ingle Coal Company have retimbered the hoisting gear at their Ingle Mine, and have sunk a new manway during the

The Crescent Coal Company have installed a new set of first motion hoisting engines, built a new engine room and have remodeled the tippie at their Unity Mine. This mine is now the largest producer in the county.

The Sunnyside Coal Company have retimbered the hoisting shaft at the Sunnyside Mine and built a new tippie, in addition to extensive repairs in the interior of the mine.

WARRICK COUNTY.

The Charles Menden Coal Company have equipped their De Forrest Mine with compressed air punching machines, and have installed a ten-foot ventilating fan. The ventilation here had previously been furnished by a furnace. Since the installing of the fan conditions have improved very much.

CHANGES IN OWNERSHIP OF MINING PROPERTIES.

The Fortner Mine, located near Turner, in Clay County, formerly owned by the C. Ehrlich Coal Company, was sold to the Star Union Coal & Oil Company in May. The mine, for some reason, has been operated but two months by the present owners.

The Little Giant Mine, owned by the L. T. Dickason Coal Company, changed hands in October, and is now the property of the Coal Bluff Mining Company. This mine is located on the Monon branch of the I. C. Railroad, in Sullivan County.

The Rhodes Mine, located on the C. & E. I. R. R., near Clinton, in Vermillion County, formerly the property of the Rhodes Coal Company, was sold in January to J. K. Deering & Co., of Chicago, who are now operating it to its full capacity.

The Star No. 2 Mine, located at Newburg, in Warrick County, owned by the John Archibald Coal Company, was purchased during the spring by the Ohio River Coal Company. This mine has been operated for a number of years as a local mine, furnishing employment for less than ten miners. Since changing hands the present company have sunk a manway and made numerous other improvements, with a view of increasing the output, and about thirty miners are now employed.

ABANDONED MINES.

Ten mines were abandoned during the year, six of which were block and four bituminous mines. We give herewith a list of the names of abandoned mines, companies operating same, date of abandonment, and the counties in which the mines were located:

CLAY COUNTY.

Brazil Block Coal Company, Diamond No. 5; mine abandoned September 15.

Zellar, McClellan & Co., Lawrence No. 6; mine abandoned May 30.

Crawford Coal Company, Crawford No. 2; mine abandoned June 8.

Crawford No. 7; abandoned during the month of November.

Eureka Block Coal Company, Eureka No. 3; mine abandoned during the month of January.

DAVIESS COUNTY.

Cabel & Kaufman Coal Company, Cabel No. 9; mine flooded and abandoned in March.

Daviess County Coal Company, Montgomery No. 2; mine abandoned March 5.

PARKE COUNTY.

New Century Coal Company, New Century; mine abandoned in May.

Crawford Coal Company, McIntosh No. 3, or Crawford No. 10; mine abandoned May 9.

SULLIVAN COUNTY.

Hymera Coal and Mining Company, Hymera No. 1; mine abandoned No. V coal seam May 1 and sunk to No. IV.

VIGO COUNTY.

Coal Bluff Mining Company, Union; mine abandoned in March.

NOTE.—The Hymera Coal and Mining Company have mined out and abandoned two coal seams at their Hymera No. 1 mine, coal No. V and No. VI.

TABLE

Showing by Counties the Name of Mine, Number of Tons Screened, Slack and Nut and Mine Run Coal, Total Tons of all Grades of Coal Produced, and the Distribution Thereof; the Production of Block and Bituminous Coal, Each Being Shown Separately, as is the Machine and Pick or Hand Mined Coal.

BLOCK COAL MACHINE MINES.

CLAY COUNTY.

NAME OF MINE.	MACHINE MINED.				PICK MINED.				DISTRIBUTION.		WAGES PAID.			
	Tons of Screened Coal.	Tons of Slack and Nut.	Tons of Mine Run.	Total Tons of all Kinds of Coal Produced.	Tons of Screened Coal.	Tons of Slack and Nut.	Tons of Mine Run.	Total Tons of all Kinds of Coal Produced.	Indiana.	Other States.	To Miners.	To Inside Day Men.	To Outside Day Men.	Total Wages.
Brazil Block No. 1.	7,220	1,447	.....	8,707	4,973	1,020	.....	5,993	7,734	6,916	\$10,776 20	\$10,896 48	\$3,378 41	\$27,851 09
Brazil Block No. 8.	10,776	2,137	.....	12,933	11,161	2,245	.....	13,426	2,921	24,078	19,081 21	23,885 48	8,386 59	51,415 28
Diamond No. 6.	2,786	861	.....	3,349	3,375	1,065	.....	11,040	5,353	9,084	11,687 01	6,860 61	4,480 15	22,737 77
Gart No. 10.	4,654	810	.....	4,861	24,001	4,805	.....	28,806	4,425	29,245	27,473 13	10,960 54	6,547 28	45,088 95
Total.	24,878	4,975	.....	29,853	49,550	9,735	.....	59,285	19,845	69,273	\$69,227 55	\$51,853 11	\$25,904 43	\$147,083 09

PARKE COUNTY.

Brazil Block No. 12.	21,816	4,492	.....	26,308	10,379	2,079	.....	12,458	5,839	32,927	\$30,099 89	\$25,067 78	\$9,038 89	\$64,206 56
Mary.	28,004	2,940	.....	30,344	2,977	.....	.....	2,977	1,477	31,844	26,655 52	18,011 40	9,075 89	53,742 81
Total.	49,820	6,832	.....	56,652	13,356	2,079	.....	15,435	7,316	64,771	\$56,755 41	\$43,079 18	\$18,114 78	\$117,949 37
Total Machine Block.	74,698	11,807	.....	86,505	62,886	11,814	.....	74,700	27,161	131,044	\$125,982 96	\$95,040 29	\$44,019 21	\$265,042 46

BITUMINOUS MACHINE MINES.

VANDERBURGH COUNTY.

Inglestide.....	60	1,576	1,636	1,445	16,484	17,929	18,811	754	\$12,820 94	\$3,041 11	\$4,040 05	\$19,702 10
Sunnyside.....		107	107	18,388	9,964	14,086	33,142	9,423	11,202 47	17,236 05	13,378 14	41,516 66
Total.....	60	1,683	1,743	19,843	9,964	30,580	60,387	10,177	\$23,823 41	\$20,277 16	\$17,418 19	\$61,518 76

GREENE COUNTY.

Black Creek.....	34,553	18,745	19,503	72,801	21,382	11,719	12,355	45,426	57,518	60,709	\$10,786 10	\$98,282 42
Island No. 1.....			62,529	81,251	33,968	11,837	69,580	69,580	52,529	69,580	9,581 18	103,644 93
Island No. 2.....	33,054	10,794	37,403	98,108	83,968	11,837	38,399	84,304	84,304	81,251	15,425 39	141,119 44
Gilmour.....			98,108	98,108					53,688	46,425	6,315 15	80,745 99
Hootier No. 1.....	12,738	11,482	19,028	43,248					16,097 71	14,270 52	9,004 07	39,462 90
Hootier No. 2.....	4,257	1,941	5,837	11,435					5,632 43	4,434 33	1,473 00	11,439 75
Island Valley No. 2.....	8,776	4,317	5,376	13,469	3,988	2,734	152	6,879	10,625 43	8,207 47	6,510 04	25,388 34
Midland.....	30,983	12,288	10,923	98,242	32,421	29	38	217	27,157 62	27,153 41	14,892 74	60,288 45
Summit No. 2.....	19,045	25,012	54,185	98,242	16,542	8,500	19,025	43,067	49,417 75	27,153 41	13,454 23	90,025 39
Glenburn.....	19,404	8,769	27,489	55,662	15,542	3,662	583	14,026	64,929 31	26,091 85	10,086 43	100,026 59
Tower Hill.....	31,331	12,589	824	44,794	9,781			87	30,002 49	13,797 85	6,887 42	60,687 76
Green Valley.....	43,112	72,218	31,564	115,833	87				69,372 24	19,006 35	11,806 89	90,185 49
Lattis Creek No. 1.....	76,030	72,218	36,884	184,132	3,090				102,119 94	37,881 72	21,942 43	161,944 09
Atlas No. 1.....	17,186	22,741	89,855	128,782					73,439 13	27,787 04	14,566 05	115,862 22
Atlas No. 2.....			5,820	6,320					16,022 63	8,748 99	7,015 46	31,787 08
Letsinger.....	5,779	2,992	431	9,252	3,888	1,518	16,488	16,488	16,022 63	3,270 66	3,669 06	15,484 18
North Western.....	33,977	28,775	17,494	80,245	1,369	400	630	2,869	38,566 45	21,064 60	10,549 17	70,210 22
Twin.....	36,335	32,227	80,993						38,566 45	9,176 65	9,303 45	57,475 60
Total.....	405,890	283,951	544,030	1,233,871	125,661	40,494	169,375	336,530	\$811,238 18	\$337,487 81	\$183,238 25	\$1,332,075 24

CLAY COUNTY.

Gifford No. 1.....	5,055		290	5,345	18,505	7,092	692	26,259	5,345	26,259	\$19,438 12	\$46,209 77
Gifford No. 2.....	10,600			10,600	88,941	19,082	2,773	59,694	10,600	59,694	29,923 92	85,698 87
Lewin.....	1,488	1,364	32,600	35,452			483	483	16,600	13,467 79	4,086 95	28,584 84
Vivian No. 4.....	11,472	7,257		18,729					15,557	13,577 88	6,972 57	28,479 25
Vivian No. 5.....	8,295	7,168	1,017	16,450					5,168	11,541 80	6,944 64	23,479 25
Island Valley No. 4.....	10,883	4,664	12,429	27,776			1,015	1,015	11,541 80	8,415 01	5,503 08	25,759 72
Gold Knob.....	8,431	4,933	1,569	15,083	77		41	118	11,321 63	6,360 90	5,269 14	19,516 90
Total.....	56,144	25,396	47,905	129,435	87,423	25,154	5,004	87,571	\$123,930 04	\$87,031 59	\$46,324 33	\$237,330 96

La Blanche	53,039	30,652	7,574	91,265	35	14	213	262	43,293	48,224	44,051	23,640	16,787	84,488
Citizens	4,084	2,030	2,729	8,813	2,725	1,420	1,756	5,861	14,724	.....	8,984	3,287	5,846	18,089
Milled	.....	.....	37,925	37,925	.....	.....	.....	.....	37,925	.....	28,125	6,476	37,100	38,541
St. Clair	11,865	6,548	7,772	19,185	5,526	5,318	169	11,013	1,295	10,185	8,112	5,645	4,178	19,036
Jackson Hill No. 4	.....	.....	2,730	17,180	.....	.....	.....	.....	1,295	12,568	8,238	3,017	2,602	13,857
Myers No. 3	9,762	22,672	8,267	40,701	615	1,610	852	3,167	5,233	35,555	16,170	10,572	5,362	37,275
Kettle Creek	180	.....	500	500	.....	.....	.....	.....	2,325	.....	1,821	.....	1,821	37,275
Phoenix No. 4	.....	.....	2,325	2,325	.....	.....	.....	.....	2,325	.....	1,821	.....	1,821	1,207
Union No. 1	.....	.....	1,150	1,150	.....	.....	.....	.....	2,305	.....	1,000	.....	302	1,502
Total	612,932	404,607	349,047	1,366,586	27,444	19,387	25,039	70,870	436,617	1,000,839	771,294	330,349	227,858	\$1,262,502

VIGO COUNTY.

Atherton	59,642	29,468	978	90,088	2,529	1,207	.....	3,736	12,648	81,176	845,794	\$16,716	88,750	\$71,261
Glen Oak	48,283	7,344	50,990	101,587	11,813	2,045	3,204	17,062	.....	118,649	55,360	37,674	14,710	107,744
Park No. 10	43,057	38,006	32,206	113,269	24,339	4,851	6,375	35,565	98,679	21,601	53,226	11,306	5,950	91,134
Sugar Creek	2,341	469	986	3,796	9,357	3,939	976	14,272	35,565	3,796	35,142	9,113	6,950	60,206
Ray No. 2	4,985	5,143	356	10,484	.....	.....	.....	.....	16,498	16,051	16,051	3,589	6,747	26,388
Forrest Park	.....	.....	3,053	3,053	.....	.....	.....	.....	3,053	.....	3,200	1,100	632	4,933
Total	153,288	80,430	88,559	322,377	48,088	12,042	10,555	70,695	166,443	226,469	\$213,774	\$89,795	\$48,086	\$351,666

WARRICK COUNTY.

Big Four	.....	.....	62,705	62,705	.....	.....	6,358	6,358	65,063	4,000	\$29,053	\$7,361	\$4,978	\$40,383
Big Vein, No. 3	.....	.....	94,566	94,566	.....	.....	.....	.....	94,566	.....	40,838	6,256	6,256	52,351
DeForest	7,343	3,720	400	11,463	.....	.....	.....	.....	5,713	5,750	5,278	1,180	1,036	7,456
Electric	3,806	1,827	91,809	97,442	.....	.....	.....	.....	34,854	62,568	42,521	12,462	6,095	61,079
Total	11,149	5,547	249,490	266,176	.....	.....	6,358	6,358	200,106	72,338	\$116,692	\$27,260	\$17,967	\$161,320

KNOX COUNTY.

Enterprise	.....	.....	2,859	2,859	.....	.....	4,465	4,465	5,798	1,536	\$2,553	\$505	\$749	\$3,908
Pine Knob	.....	.....	20	20	.....	.....	.....	.....	5	15	789	.....	1,339	2,128
Total	.....	.....	2,879	2,879	.....	.....	4,465	4,465	5,793	1,551	\$3,342	\$505	\$2,088	\$5,936
Total Bituminous Machine Mines	1,297,597	828,616	1,373,456	3,499,669	299,223	116,589	285,590	701,407	2,097,083	2,103,993	\$2,125,055	\$948,151	\$549,510	\$3,618,717

BLOCK COAL—HAND OR PICK MINES.

CLAY COUNTY.

NAME OF MINE.	PRODUCTION.				DISTRIBUTION.		WAGES.			
	Tons of Coredred Coal.	Tons of Slack and Nut Coal.	Tons of Mine-Run Coal.	Total Tons of all Kinds of Coal Produced	Indians.	Other States.	To Miners.	To Inside Day Men.	To Outside Day Men.	Total Wages Paid.
Gart No. 7	45,275	9,065	.....	54,340	31,650	22,690	\$50,243 58	\$14,181 11	\$7,345 60	\$71,770 29
Continental No. 1	16,530	3,933	.....	21,102	3,704	17,398	16,928 47	9,912 71	4,295 23	31,026 41
Reb Stock	14,836	2,665	.....	17,501	3,225	14,276	14,712 80	8,165 69	4,055 39	26,933 88
Lawrence No. 6	10,160	2,500	.....	12,660	11,276	1,384	10,176 49	2,471 14	1,235 55	13,883 18
Lawrence No. 7	30,482	7,896	.....	38,354	34,909	3,745	35,191 98	15,984 85	7,547 59	56,724 42
Corwall	13,808	1,697	.....	15,505	15,505	.....	15,297 78	4,368 69	2,318 24	21,954 71
Crawford No. 2	8,469	2,110	.....	10,579	4,773	5,806	8,432 85	1,875 16	1,449 79	11,757 80
Crawford No. 5	20,974	4,600	.....	25,573	11,403	14,348	21,129 04	6,123 52	3,809 43	31,061 19
Crawford No. 6	27,667	6,414	.....	34,081	14,903	19,178	28,935 67	7,188 98	3,804 19	39,928 84
Crawford No. 7	9,287	1,729	.....	11,016	7,283	3,733	9,432 92	3,678 61	1,988 46	15,147 98
Eureka No. 3	853	1,730	.....	916	312	604	3,947 80	146 90	558 40	4,653 00
Monarch .....	.....	.....	8,614	8,614	8,614	.....	11,100 00	3,157 95	1,180 18	15,438 13
Crawford No. 8	12,046	3,075	.....	15,121	6,150	8,971	12,926 86	4,705 90	3,483 81	20,778 57
Lower Vein	11,655	3,015	.....	14,670	6,093	8,577	15,819 77	6,905 47	4,910 66	27,635 90
Crawford No. 9	2,997	701	.....	3,698	1,400	2,298	3,717 49	1,966 66	1,210 43	6,954 58
Brazil Block No. 4	4,022	810	.....	4,832	393	4,437	6,007 81	8,908 41	4,681 05	19,597 27
Superior No. 4	2,576	560	.....	3,136	3,136	.....	3,460 50	2,124 01	1,081 99	8,646 50
Worlds Fair No. 2	2,660	540	.....	3,200	3,200	.....	3,947 73	1,520 52	729 03	6,197 28
Crawford No. 1	2,374	437	.....	2,811	1,700	1,111	2,854 19	2,401 54	1,437 15	6,692 88
Total	236,671	51,776	9,742	298,189	169,808	128,586	\$276,183 73	\$103,846 72	\$56,752 37	\$436,782 82

PARKE COUNTY.

McIntosh No. 3.....	4,384	725	.....	5,109	.....	30,801	5,109	\$4,377 78	\$1,784 59	\$1,159 48	\$7,301 83
Superior No. 1.....	51,191	12,700	.....	64,298	.....	39,331	83,187	53,646 10	20,289 66	10,119 81	87,025 47
Superior No. 2.....	46,736	17,911	467	59,118	.....	28,397	28,397	52,984 72	21,609 20	10,587 16	84,931 47
Superior No. 3.....	27,004	7,975	571	34,779	.....	15,792	18,937	34,642 30	12,850 27	5,266 50	53,939 97
Par-Amerique.....	43,927	7,410	.....	57,028	.....	23,931	33,477	64,451 50	21,271 10	7,778 60	80,332 36
Brazil Block No. 9.....	39,666	8,060	.....	47,756	.....	11,899	35,857	44,271 77	18,068 24	7,510 93	69,550 94
Total.....	218,168	48,081	1,429	297,678	.....	111,694	155,984	\$247,724 07	\$95,509 52	\$39,997 46	\$383,231 05
Total hand mine—block.....	454,839	99,857	11,171	565,867	.....	291,297	284,570	\$523,907 80	\$199,866 24	\$96,749 83	\$820,013 87

BITUMINOUS—HAND OR PICK MINES.

CLAY COUNTY.

Cloverland No. 1.....	70,356	23,170	16,581	110,107	.....	110,107	.....	\$71,109 22	\$17,719 84	\$8,881 47	\$97,690 03
Cloverland No. 2.....	33,738	10,866	1,883	46,517	.....	44,149	2,368	10,294 75	8,241 00	3,098 00	52,402 68
Fair View.....	13,103	9,416	.....	22,519	.....	13,881	8,638	18,064 19	2,409 19	2,018 00	18,443 41
Kortner.....	4,058	2,354	.....	6,412	.....	7,352	1,970	6,616 45	2,561 33	1,166 53	10,344 31
Klondike.....	28,034	12,093	3,462	41,589	.....	39,645	1,944	25,061 73	7,563 24	6,121 53	38,746 01
Glenn No. 2.....	1,511	27,712	.....	1,586	.....	.....	1,586	1,625 40	1,486 16	768 55	3,220 10
Peart.....	31,579	21,743	1,943	53,867	.....	35,194	20,173	32,429 85	11,181 03	5,088 06	48,698 93
Glenn No. 1.....	23,922	6,546	.....	29,593	.....	.....	29,593	24,792 15	6,506 30	2,966 05	34,068 50
Total.....	206,367	85,494	23,869	315,730	.....	250,328	65,402	\$214,945 79	\$57,917 58	\$30,955 58	\$303,518 95

DAVISS COUNTY.

Cable No. 9.....	.....	.....	12,212	12,212	.....	12,212	.....	\$7,489 75	\$3,718 10	\$1,386 40	\$12,594 26
Montgomery No. 2.....	1,976	285	1,089	3,300	.....	2,200	.....	1,648 15	280 85	590 35	2,729 35
Montgomery No. 3.....	60,862	6,906	4,157	71,925	.....	47,738	24,187	56,760 55	18,527 47	10,886 40	86,174 43
Mutual.....	11,900	1,500	13,500	26,900	.....	16,100	10,800	19,700 50	5,990 00	3,755 00	29,445 50
Union.....	.....	.....	6,421	6,421	.....	6,421	.....	3,963 40	881 02	831 35	5,675 77
Mandach.....	68	33	12,411	12,512	.....	12,512	.....	7,952 68	990 68	935 48	9,578 82
Total.....	74,806	8,724	49,740	133,270	.....	97,183	36,087	\$97,715 03	\$30,398 12	\$13,384 98	\$146,498 12

BLOCK COAL—HAND OR PICK MINES—Continued.

FOUNTAIN COUNTY.

NAME OF MINE.	PRODUCTION.				DISTRIBUTION.		WAGES.			
	Tons of Screened Coal.	Tons of Slack and Nut Coal.	Tons of Mine-Run Coal.	Total Tons of all Kinds of Coal Produced.	Indiana.	Other States.	To Miners.	To Inside Day Men.	To Outside Day Men.	Total Wages Paid.
Rush.....	18,592	5,763	11,426	35,771	35,771	.....	\$27,260 71	\$7,410 35	\$4,260 50	\$38,931 56
Silverwood.....	3,329	1,900	14,910	20,139	19,473	1,666	14,004 59	4,524 23	2,931 94	21,460 76
Total.....	21,921	7,663	26,336	55,910	54,244	1,666	\$41,265 30	\$11,934 58	\$7,192 44	\$60,392 32

GIBSON COUNTY.

Oswald.....	17,424	18,720	18,781	54,925	50,013	4,912	\$32,471 58	\$12,033 30	\$11,302 76	\$55,897 66
Massey.....	3,071	2,303	23,694	28,998	23,175	5,823	20,199 47	9,463 13	2,239 48	31,991 08
Ft. Branch.....	.....	.....	48,755	1,672	1,672	.....	1,687 00	219 00	287 50	2,193 50
Total.....	20,495	21,023	44,077	85,595	74,860	10,735	\$54,358 05	\$21,714 43	\$14,009 76	\$90,082 24

GREENE COUNTY.

Island No. 3.....	.....	.....	47,493	47,493	.....	47,493	\$30,399 24	\$12,065 88	\$6,495 00	\$48,962 02
Island No. 5.....	.....	.....	19,632	19,717	.....	19,717	14,104 10	6,099 36	2,913 32	23,207 78
Island Valley No. 3.....	27,624	13,392	37,389	78,555	18,496	34,859	49,298 28	14,211 04	7,881 33	71,390 45
South Linton.....	43,469	23,921	48,755	116,145	76,552	39,693	70,998 92	20,443 87	7,070 75	98,493 54
Vulcan.....	1,882	771	3,016	7,669	7,669	.....	5,092 04	1,558 97	1,544 66	8,195 67
Templeton.....	3,678	230	55,940	59,815	59,815	.....	84,758 15	11,634 45	6,985 60	103,366 20
Victoria.....	63,659	46,618	174,572	286,209	282,445	2,764	194,273 98	23,844 90	13,009 03	207,127 96
Antioch.....	27,826	23,415	20,979	71,220	62,741	8,479	52,840 80	21,587 18	8,239 34	82,667 32

Fry.....	22,142	9,190	9,190	7,985 00	3,560 00	3,670 00	15,196 00
North Linton.....	10,400	6,991	89,533	28,353 98	6,734 87	3,562 96	38,661 80
Pennsylvania.....	2,574	893	4,207	3,991 98	828 29	1,761 55	6,471 82
Total.....	193,166	118,680	738,563	\$461,836 47	\$127,569 81	\$92,824 48	\$632,229 76

KNOX COUNTY.

Bicknell.....	17,461	12,933	45,041	28,561	16,480	\$7,732 72	\$5,826 35	\$37,634 83
Knox.....	10,378	10,784	30,625	11,741	18,684	6,206 02	3,165 37	25,593 15
Lynn.....	511	41,161	29,191	29,191	11,970	5,221 11	5,200 92	34,409 48
Prospect Hill.....	4,801	200	1,002	1,002	824 75	422 73	182 50	1,428 75
Wheatland.....	33,151	2,363	25,394	23,506	1,868	4,106 69	4,199 86	27,128 68
Total.....	117,367	30,086	260,319	195,854	64,465	\$33,118 63	\$33,329 49	\$307,730 22

PARKE COUNTY.

Lucia.....	15,596	14,736	37,150	25,934	11,216	\$21,594 12	\$5,478 73	\$38,358 94
Meca No 1.....	379	187	3,080	2,884	196	1,937 42	581 05	6,550 98
New Century.....	172	85	659	659	1,580 00	1,101 00	500 00	3,161 00
Minshall No. 1.....	85,700	17,143	7,493	82,000	94,784 91	36,854 61	11,248 08	142,887 60
Minshall No. 2.....	6,891	1,565	11,280	11,280	10,636 07	2,594 23	1,053 69	17,988 57
Raccoon.....	8,629	4,290	8,397	8,397	6,319 73	2,540 49	1,309 76	9,943 69
Meca No. 4.....	671	5,944	18,963	6,766	12,097	3,750 00	92 00	17,451 01
C. B. Harrison.....	64,335	671	64,335	671	12,620	18,560 88	9,760 62	66,737 66
Coz No. 3.....	117,367	30,086	260,319	195,854	64,465	\$33,118 63	\$33,329 49	\$307,730 22
W. P. Harrison.....	117,367	30,086	260,319	195,854	64,465	\$33,118 63	\$33,329 49	\$307,730 22
Total.....	117,367	30,086	260,319	195,854	64,465	\$33,118 63	\$33,329 49	\$307,730 22

PERRY COUNTY.

Troy.....	7,275	7,275	7,275	7,275	7,275	\$1,387 52	\$1,268 78	\$7,959 41
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BLOCK COAL—HAND OR PICK MINES—Continued.

PIKE COUNTY.

NAME OF MINE.	PRODUCTION.			DISTRIBUTION.		WAGES.		
	Tons of Screened Coal.	Tons of Black and Nut Coal.	Tons of Mine-Run Coal.	Total Tons of all Kinds of Coal Produced.	Indiana	Other States.	To Miners.	To Men. Inside Day
							To Outside Day	Total Wages Paid.
Aberdeen.....	13,016	6,346	2,324	2,324	2,324	4,385	\$719 18	\$2,624 67
Ayrshire No. 3.....	30,345	20,253	1,682	21,044	16,659	28,164	5,109 88	19,073 72
Ayrshire No. 4.....	606	753	39,734	90,332	62,168	21,954	14,374 24	72,305 69
Ayrshire No. 5.....	3,538	4,668	3,476	4,835	3,337	1,498	1,024 64	4,666 31
Blackburn.....	35,232	47,145	3,148	11,354	7,629	3,725	2,158 92	10,092 68
Little.....	3,587	1,901	9,670	92,047	63,510	28,537	14,571 53	74,306 79
Rogers.....	Not reported.	17,439	2,674	2,674	2,674	.....	457 42	1,919 75
Hartwell.....	12,305	11,404	70,427	75,915	45,270	30,645	12,844 62	64,814 15
Petersburg.....	Report ed with No. 2.	7,459	41,149	19,291	19,291	21,868	15,070 83	41,608 95
Winslow Nos. 2 and 6.....	.....	.....	.....	.....	7,459	.....	1,738 00	6,665 52
Winslow No. 5.....	.....	.....	.....	.....	230,321	118,812	\$32,925 67	\$238,108 23
Carbon.....	98,630	92,470	168,083	349,183	.....	.....	.....	.....
Total.....	.....	.....	.....	.....	.....	.....	.....	.....

SULLIVAN COUNTY.

NAME OF MINE.	PRODUCTION.			DISTRIBUTION.		WAGES.		
	Tons of Screened Coal.	Tons of Black and Nut Coal.	Tons of Mine-Run Coal.	Total Tons of all Kinds of Coal Produced.	Indiana	Other States.	To Miners.	To Men. Inside Day
							To Outside Day	Total Wages Paid.
White Ash.....	1,680	880	29,082	31,662	13,817	17,895	\$5,310 80	\$30,702 69
Freemant.....	21,145	9,774	12,821	30,919	6,650	24,269	6,358 01	32,257 77
Island No. 4.....	4,649	1,508	18,479	18,479	18,479	.....	10,428 29	34,678 09
Bruliettes Creek No. 6.....	11,760	10,509	8,561	31,250	2,404	29,246	9,239 27	51,988 27
Shirley Hill.....	767	11,010	11,777	11,777	11,777	.....	2,314 20	18,773 25
Superior.....	14,021	9,214	4,516	28,451	22,102	6,349	5,653 20	30,231 18
Total.....	54,042	32,086	65,790	152,518	74,829	77,689	\$39,299 83	\$176,244 26

VANDERBURGH COUNTY.

Diamond.....	17,464	11,125	7,748	36,337	36,337	.....	36,337	\$23,575 19	\$1,551 99	\$1,376 52	\$32,513 60
First Avenue.....	9,561	5,659	5,399	20,619	20,619	.....	18,748	14,983 50	8,221 45	3,649 45	21,454 40
Union.....	9,184	4,609	9,184	22,977	22,977	.....	9,184	19,038 95	3,016 95	4,210 05	28,365 95
Unity.....	29,697	5,079	60,786	96,562	96,562	.....	95,562	67,434 60	15,724 87	9,469 50	92,628 47
Total	65,906	26,472	83,117	175,495	175,495	.....	175,624	\$126,162 24	\$26,534 66	\$21,705 52	\$175,392 42

VERMILION COUNTY.

Bruliettes Creek No. 3.....	1,933	1,490	80,675	81,118	81,118	.....	3,607	94,610 10	\$15,594 40	95,178 05	985,377 55
Bruliettes Creek No. 5.....	81,521	49,985	59,528	190,134	190,134	.....	18,606	110,463 76	25,751 85	9,588 35	146,653 96
Buckeye. (Not reported. New mine.).....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Eureka.....	.....	.....	.....	11,556	11,556	.....	11,556	7,593 28	2,977 93	2,523 64	13,335 90
Crown Hill No. 1.....	43,204	18,126	83,692	140,222	140,222	.....	109,742	97,619 10	23,420 84	4,444 10	126,483 84
Crown Hill No. 2.....	18,617	4,686	90,511	109,093	109,093	.....	84,514	61,996 24	16,654 27	3,968 60	83,621 01
Oak Hill.....	29,829	17,191	57,478	104,493	104,493	.....	104,493	60,993 47	18,570 74	8,789 80	85,064 01
Prince.....	.....	.....	174,710	174,710	174,710	.....	174,710	104,593 62	28,276 69	10,730 61	143,689 92
Willow Grove.....	42,541	17,325	38,506	98,172	98,172	.....	98,172	49,226 10	50,413 65	5,064 60	144,694 25
Rhodes.....	38,275	32,640	39,551	130,465	130,465	.....	17,112	93,712 34	22,712 37	11,592 85	118,017 66
Riverside.....	.....	1,651	15,717	21,234	21,234	.....	3,669	15,426 45	2,726 80	3,093 25	21,246 60
Maple Valley No. 1.....	3,966	.....	60,353	60,353	60,353	.....	57,369	57,349 65	13,088 95	6,925 94	57,364 55
Maple Valley No. 2.....	.....	.....	3,194	3,194	3,194	.....	3,194	2,500 00	1,100 00	500 90	4,100 00
Total	273,906	142,973	715,771	1,131,750	1,131,750	.....	126,791	\$677,311 11	\$181,068 36	\$72,649 79	\$831,049 26

VIGO COUNTY.

Brick Works.....	.....	.....	9,644	9,644	9,644	.....	9,644	\$7,534 66	\$2,066 41	\$1,491 48	\$11,092 55
Chicago No. 6.....	1,348	615	6,823	8,786	8,786	.....	8,786	5,627 55	3,765 50	2,553 37	11,336 42
Diamond.....	62,404	27,700	28,502	118,600	118,600	.....	118,606	76,088 60	26,401 20	9,491 38	111,981 35
Peoples.....	28,597	11,590	2,693	42,880	42,880	.....	42,880	29,447 00	11,606 40	6,902 40	46,355 80
Lawton.....	71,706	37,018	48,715	157,439	157,439	.....	157,439	100,971 65	21,943 00	8,844 25	131,778 90
Union.....	10,167	3,940	1,197	15,304	15,304	.....	15,304	9,834 30	2,926 50	2,442 00	15,203 80
Ehrlich.....	1,169	835	1,197	2,004	2,004	.....	2,004	1,181 84	453 74	240 66	1,866 24
Grant No. 2.....	24,811	29,541	90,512	144,864	144,864	.....	38,429	77,952 33	25,073 64	10,927 31	113,953 28
Hector.....	18,294	12,825	199	31,308	31,308	.....	30,847	16,610 76	9,904 91	6,215 85	34,431 52
Klondyke.....	9,942	7,315	37,259	54,536	54,536	.....	54,536	28,331 25	12,789 45	7,711 50	46,832 20
Redbird.....	19,696	15,027	10,772	45,494	45,494	.....	45,494	23,633 45	9,806 63	4,979 06	37,619 39
Rosebud No. 2.....	59,718	26,526	7,294	93,538	93,538	.....	93,538	58,474 64	20,398 02	5,903 87	84,096 53
Royal No. 1.....	20,508	10,438	50,857	81,803	81,803	.....	81,239	55,564 18	14,332 34	4,749 39	74,645 91

BLOCK COAL—HAND ORPICK MINES—Continued.

VIGO COUNTY—Continued.

NAME OF MINE.	PRODUCTION.				DISTRIBUTION.		WAGES.			
	Tons of Screened Coal.	Tons of Black and Nut Coal.	Tons of Mine-Run Coal.	Total Tons of all Kinds of Coal Produced.	Indiana.	Other States.	To Miners.	To Inside Day Men.	To Outside Day Men.	Total Wages Paid.
Larimer.....	18,136	17,304	17,460	17,460	16,019	1,441	9,638 90	1,951 56	1,566 70	13,157 16
Broadhurst.....	31,926	30,628	23,809	59,249	47,448	11,801	32,577 11	7,313 85	7,664 39	47,555 35
Miami No. 2.....	31,619	17,511	9,309	71,863	67,947	71,863	43,745 95	11,901 83	4,975 39	60,623 17
Deep Vein No. 1.....	28,453	17,339	23,929	73,059	55,255	6,112	40,392 99	9,314 68	6,144 25	55,851 92
Greenfield No. 1.....	26,453	17,339	11,463	55,255	57,360	.....	37,308 73	6,799 00	6,514 40	50,622 13
Lost Creek.....	24,433	19,874	17,281	61,538	57,360	4,228	40,697 01	7,863 04	6,471 99	55,032 04
Miami No. 3.....	5,243	3,004	12,762	21,009	.....	21,009	9,294 49	3,624 24	1,765 60	14,704 33
Miami No. 1.....	80,592	79,808	.....	160,400	.....	160,400	90,960 42	19,096 25	7,966 03	118,012 70
Total.....	546,761	369,838	410,520	1,326,109	902,195	423,914	797,047 84	228,932 39	113,851 26	1,139,831 49

WARRICK COUNTY.

Alt Line.....	3,450	1,800	2,150	7,400	2,420	4,980	\$3,908 25	\$986 10	\$459 70	\$5,354 05
Chandler.....	5,460	2,830	3,560	11,650	3,250	8,400	7,219 95	1,207 30	971 55	9,198 80
Star No. 1.....	.....	.....	32,624	32,624	32,624	.....	15,438 78	5,428 01	3,287 62	24,154 41
Burke.....	.....	.....	17,692	17,692	17,692	.....	8,343 71	1,686 65	2,160 81	13,191 18
Total.....	8,910	4,630	55,325	69,366	55,986	13,380	\$34,910 69	\$9,308 07	\$6,879 68	\$51,098 44
Total hand mine bituminous coal.....	1,715,418	965,595	2,263,243	4,944,256	2,899,365	2,044,891	\$3,090,087 31	\$810,951 49	\$462,592 19	\$4,463,630 99

RECAPITULATION.

Showing Total Production and Wages of Indiana Mines for 1904.

TOTAL PRODUCTION OF BLOCK COAL.

	MACHINE MINED.				PICK MINED.				DISTRIBUTION.		WAGES.			
	Tons of Screened Coal.	Tons of Slack and Nut Coal.	Tons of Mine-Run Coal.	Total Tons of all Kinds of Coal Produced.	Tons of Screened Coal.	Tons of Slack and Nut Coal.	Tons of Mine-Run Coal.	Total Tons of all Kinds of Coal Produced.	Indiana.	Other States.	Miners.	To Inside Day Men.	To Outside Day Men.	Total Wages Paid.
Total production block machine mines.....	74,698	11,807	.....	86,505	62,886	11,814	.....	74,700	27,161	134,044	\$125,982 96	\$95,040 29	\$44,019 21	\$265,042 46
Total production block pick mines.....	.....	.....	.....	.....	451,839	99,857	11,171	555,867	281,297	284,570	523,907 80	199,356 24	98,749 83	820,013 87
Total block coal.....	74,698	11,807	.....	86,505	517,725	111,671	11,171	640,567	308,458	418,614	\$649,890 76	\$234,396 53	\$140,769 04	\$1,085,055 33

TOTAL PRODUCTION OF BITUMINOUS COAL.

Total bituminous machine mines.....	1,297,597	828,616	1,373,456	3,499,669	299,228	113,589	285,590	701,407	2,097,063	2,103,993	\$2,125,065 56	\$946,151 09	\$545,510 41	\$3,616,717 06
Total bituminous pick mines....	.....	.....	.....	.....	1,715,418	965,595	2,293,243	4,944,256	2,899,365	2,044,591	3,090,087 31	910,951 49	462,592 19	4,463,930 99
Total bituminous coal..	1,297,597	828,616	1,373,456	3,499,669	2,014,646	1,082,184	2,548,833	5,645,663	4,996,448	4,148,584	\$5,215,142 37	\$1,859,102 58	\$1,006,102 60	\$81,080,248 05
Total machined coal.....	1,372,295	840,423	1,373,456	3,586,174	362,114	128,403	285,590	776,107	2,124,244	2,239,037	\$2,251,038 52	\$1,043,191 38	\$587,529 62	\$3,981,759 52
Total pick mined coal.....	.....	.....	.....	.....	2,170,297	1,065,452	2,274,414	5,510,123	3,180,662	2,259,461	3,613,995 11	1,110,307 75	566,342 02	6,283,544 86
Grand total..	3,904,666	2,034,278	3,933,460	9,872,404	.....	.....	.....	.....	5,304,906	4,567,498	\$6,865,033 63	\$2,163,499 11	\$1,146,871 64	\$99,166,404 38

TABLE,

Showing Comparative Statement of Coal Produced, Wages Paid and Number of Employees for 1903 and 1904.

	1903.	1904.	Decrease of 1904 Under 1903.	Increase of 1904 Over 1903.
Total tonnage produced.....	9,992,553	9,872,404	120,149	.....
Total wages paid.....	\$9,149,572 12	\$9,165,404 38	.....	\$15,832 26
Total employees	15,128	17,838	.....	2,710

TABLE

Showing Number of Miners, Machine Runners and Helpers, Loaders, Inside Day and Monthly Men, Persons Employed Outside; Total Number of Employees at Each Mine, Number of Days Worked and Number of Mules Used; Totals by Counties, Expenditure for Improvements.

CLAY COUNTY.

NAME OF MINE.	Pick Miners.	Machine Runners and Helpers.	Loaders.	Inside Day and Monthly Men.	Outside Day Men.	Total Employees.	Days Worked.	Mules Used.	Fatal Accidents.	Improvements.
Brazil Block No. 1.....	9	4	8	12	9	33	285	9	.....	.....
Brazil Block No. 8.....	32	6	14	20	9	63	193	9	.....	.....
Diamond No. 5.....	24	2	9	7	4	49	174	4	.....	.....
Galt No. 1.....	66	.....	.....	20	10	126	183	4	.....	.....
Galt No. 10.....	28	6	11	12	9	61	207	4	.....	.....
Continental No. 1.....	33	.....	.....	6	9	49	78	2	.....	.....
Rebscock No. 1.....	41	.....	.....	10	6	57	239	1	.....	.....
Cloverland No. 1.....	118	.....	.....	34	17	167	184	11	.....	.....
Cloverland No. 2.....	62	.....	.....	6	9	76	163	1	.....	.....
Lawrence No. 5.....	46	.....	.....	12	7	63	191	2	.....	.....
Lawrence No. 7.....	55	.....	.....	6	4	63	201	2	.....	.....
Fair View.....	57	.....	.....	12	9	77	180	2	.....	.....
Cornwall.....	32	.....	.....	7	4	43	172	1	.....	.....
Crawford No. 2.....	31	.....	.....	5	4	40	116	2	.....	.....
Crawford No. 5.....	41	.....	.....	3	9	50	157	2	.....	.....
Crawford No. 6.....	23	.....	.....	15	9	47	221	2	.....	.....
Crawford No. 7.....	23	.....	.....	15	9	47	163	2	.....	.....
Eureka No. 3.....	23	.....	.....	4	9	34	103	1	.....	.....
Fortnet.....	23	.....	.....	3	9	34	74	2	.....	.....
Kinadyke.....	32	.....	.....	3	9	44	73	1	.....	.....
Gifford No. 1.....	37	8	10	13	4	72	73	1	.....	.....
Gifford No. 2.....	30	6	18	14	13	76	170	1	.....	.....
Glenn No. 1.....	70	6	.....	16	8	100	150	1	.....	.....
Monarch.....	17	.....	.....	10	2	38	111	2	.....	.....
Pearl.....	100	.....	.....	20	2	128	239	2	.....	.....
Lewis.....	2	10	30	.....	7	43	140	2	.....	.....
Vivian No. 4.....	.....	8	17	9	9	58	187	2	.....	.....
Vivian No. 5.....	6	6	21	9	7	43	215	2	.....	.....
Vivian No. 6.....	50	.....	.....	7	9	64	238	2	.....	.....
Crawford No. 8.....	.....	.....	.....	7	9	62	193	2	.....	.....
TOTALS.....	6	6	21	7	9	62	1,256 00	4	.....	1,256 00
	.....	.....	.....	.....	.....	.....	300 00	.....	.....	300 00
	.....	.....	.....	.....	.....	.....	300 00	.....	.....	300 00

Showing Number of Miners, Machine Runners and Helpers, Etc.—Continued.

CLAY COUNTY—Continued.

NAME OF MINE.	Pick Miners.	Machine Runners and Helpers.	Leaders.	Inside Day and Monthly Men.	Outside Day Men.	Total Employees.	Days Worked.	Mules Used.	Fatal Accidents.	Improvements.
Lower Vein No. 1.....	40	.....	.....	10	5	55	243	.....	1	.....
Crawford No. 9.....	31	.....	.....	4	6	40	72	.....	.....	3,427 75
Brazil No. 4.....	57	.....	.....	21	16	94	76	.....	.....	.....
Glenn No. 2.....	17	.....	.....	2	4	23	66	.....	.....	2,661 69
Gold Knob.....	.....	8	20	14	11	53	131	.....	.....	.....
World's Fair.....	28	.....	.....	6	4	38	99	.....	.....	.....
Crawford No. 4.....	27	.....	.....	8	5	40	47	.....	.....	.....
Superior No. 4.....	24	8	20	8	6	38	114	.....	.....	.....
Island Valley No. 4.....	.....	8	20	8	6	44	97	.....	.....	.....
Total.....	1,529	72	178	470	253	2,502	5,535	184	3	\$3,835 80

DAVIESS COUNTY.

Cabel No. 9.....	55	.....	.....	16	7	78	45	3	.....	.....
Montgomery No. 2.....	15	.....	.....	2	2	19	39	3	.....	.....
Montgomery No. 3.....	110	.....	.....	28	12	150	217	16	.....	.....
Mutual.....	60	.....	.....	11	7	78	209	9	.....	\$1,115 10
Union.....	19	.....	.....	2	2	25	164	2	.....	.....
Mandabach.....	12	.....	.....	2	3	17	228	2	.....	.....
Total.....	271	.....	.....	63	33	367	902	35	.....	\$1,115 00

FOUNTAIN COUNTY.

Rush.....	45	.....	.....	11	7	63	222	3	.....	\$305 00
Silverwood.....	28	.....	.....	6	6	38	238	3	.....	450 00
Total.....	71	.....	.....	17	13	101	460	6	.....	\$755 00

GIBSON COUNTY.

Oswald	51	21	13	85	156	12	\$5,515 98
Mary	44	10	5	59	176	5	600 00
Ft. Branch	14	2	3	19	21	1	50 00
Total	109	33	21	163	353	18	\$6,065 98

GREENE COUNTY.

	64	10	60	98	9	171	146	14	2	
Black Creek.....	54	10	60	38	9	171	146	14	2	
Inland No. 1.....	73	12	24	50	12	171	204	19		
Inland No. 2.....	74	10	24	47	10	197	172	17	1	
Inland No. 3.....	70	28	33	19	14	99	150	9		
Inland No. 5. (No report.).....										
Gilmour.....	20	16	06	52	16	200	144	22		
Hooster No. 1.....		6	26	15	4	61	215	4		
Hooster No. 2.....		4	16	6	10	31	40	2		
Inland Valley No. 2.....	20	6	16	6	10	58	74	8		\$856 67
Inland Valley No. 3.....	99			30	13	142	130	16		
South Linton.....	120			31	9	170	142	17		
Midland.....	2	12	50	25	10	99	116	7		
Vulcan.....	30			4	6	61	61	2		
Summit No. 2.....	6	18	92	55	8	179	186	20		
Templeton.....	52			13	9	74	248	7		
Victoria.....	204			45	16	265	241	18	1	
Glenburn.....	47	10	56	48	15	176	174	20	2	
Antioch.....	81			31	13	125	212	10		
Tower Hill.....	21	10	41	12	10	94	148	5		
Green Valley.....	1	18	99	30	12	160	135	13		500 00
Lattis Creek No. 1.....	17	18	100	50	21	206	252	10		252 00
Atlas No. 1.....	20	18	90	45	12	185	211	16	1	540 00
Atlas No. 2.....	40	4	16	9	8	77	122	18		
Fry.....	31			5	3	39	159	3		
Leisinger.....		8	20	6	4	38	180	2		
North Western.....	15	10	70	37	12	144	160	9		90 40
Twin. (Not reported.).....										
North Linton.....	60			13	9	83	170	7		800 00
Pennsylvania.....	20			5	6	31	19	2		
Total.....	1,183	208	910	726	277	3,304	3,908	292	7	\$10,049 13

Showing Number of Miners, Machine Runners and Helpers, Etc.—Continued.
KNOX COUNTY.

NAME OF MINE.	Pick Miners.	Machine Runners and Helpers.	Loaders.	Inside Day and Monthly Men.	Outside Day Men.	Total Employees.	Days Worked.	Mules Used.	Fatal Accidents.	Improvements.
Bicknell.....	47	.....	.....	18	10	70	160	7	.....	.....
Knox.....	63	.....	.....	12	9	84	84	6	.....	\$3,200 00
Dynn.....	50	.....	.....	12	10	72	136	3	.....	.....
Prospect Hill.....	17	.....	.....	4	4	25	25	3	.....	.....
Enterprise.....	18	6	4	6	6	40	53	2	2	1,250 00
Wheatland.....	32	2	9	9	14	43	169	2	.....	2,061 40
Pine Knot.....	.....	.....	.....	.....	.....	34	23	1	.....	.....
Total.....	227	10	13	60	58	368	643	28	2	\$6,531 40

PARKE COUNTY.

Brazil Block No. 12.....	22	12	26	29	9	98	203	10	.....	.....
Cox No. 3.....	68	.....	.....	21	12	101	191	9	.....	.....
Lucia.....	45	.....	.....	17	6	67	188	12	.....	\$350 00
New Century.....	52	12	41	15	12	73	65	11	.....	.....
Lyford No. 1.....	20	14	36	25	10	94	195	9	.....	1,870 00
Mary.....	9	.....	.....	6	4	38	142	8	.....	2,213 69
McIntosh No. 3.....	29	.....	.....	31	8	187	183	2	.....	.....
Superior No. 1.....	148	.....	.....	35	12	152	194	10	.....	.....
Superior No. 2.....	105	105	104	16	6	88	202	5	.....	.....
Superior No. 3.....	66	.....	.....	50	11	191	280	19	.....	.....
Minshall No. 1.....	130	17	.....	23	13	26	239	2	.....	755 37
Minshall No. 2.....	17	.....	.....	6	4	171	169	9	.....	.....
Pan American.....	135	.....	.....	33	9	123	178	10	.....	.....
Brazil Block No. 9.....	81	81	.....	33	6	46	24	4	.....	.....
Raccoon.....	32	23	32	15	9	108	178	7	1	.....
Park No. 11.....	30	23	.....	6	3	22	87	4	.....	.....
Mecca No. 4.....	13	.....	81	14	12	157	189	14	.....	.....
Mecca No. 3.....	42	8	.....	.....	.....	.....	.....	.....	.....	.....
C. B. Harrison. (No mine boss report.)	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
W. P. Harrison. (No mine boss report.)	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Total.....	1,044	68	316	374	150	1,852	2,902	157	1	\$6,188 96

PERRY COUNTY.

Troy	16	.....	.....	3	3	22	164	2	.....
Total	16	.....	.....	3	3	22	164	2	.....

PIKE COUNTY.

Aberdeen	13	.....	.....	3	3	19	77	3	.....	\$145 00
Ayrshire No. 3	60	.....	.....	20	7	87	77	15	2	.....
Ayrshire No. 4	115	.....	.....	28	10	153	165	12	1	313 87
Ayrshire No. 5	33	.....	.....	5	5	43	40	3	.....	1,085 02
Blackburn	60	.....	.....	14	7	71	38	10	.....	.....
Little	122	.....	.....	36	12	170	144	13	.....	.....
Rogers, (No mine boss report) .....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Hartwell	98	.....	.....	20	13	131	181	12	.....	1,082 35
Petersburg	16	.....	.....	16	6	63	21	6	.....	.....
Carbon	18	.....	.....	6	4	23	135	2	.....	325 00
Winslow No. 2	50	.....	.....	8	72	190	9	.....	.....	1,338 62
Winslow No. 5	30	.....	.....	8	6	44	66	.....	.....	.....
Winslow No. 3, (No mine boss report) .....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Ayrshire No. 6, (Idle; no report) .....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Total	629	.....	.....	164	146	939	953	74	5	\$4,189 86

SULLIVAN COUNTY.

Bunker Hill	18	6	23	22	30	99	207	9	.....	.....
Caledonia	16	12	35	35	15	173	222	10	1	.....
Dugan .....	.....	8	17	17	7	68	95	7	.....	.....
Green Hill	8	6	32	20	11	80	130	9	.....	\$640 00
Hymers No. 1	44	14	104	53	19	234	48	15	.....	.....
New Lin Hill No. 2	8	6	14	13	5	46	231	4	.....	1,621 67
Jackson No. 1 .....	.....	18	107	34	15	176	171	19	1	.....
Phoenix No. 3	47	8	12	34	15	113	90	11	.....	.....
Shelburn	15	.....	.....	4	4	23	62	3	.....	.....
Star City .....	.....	4	13	4	9	34	108	.....	.....	.....
White Ash	88	12	62	43	24	140	177	12	.....	498 14
Greeman	37	.....	.....	10	6	52	136	4	.....	519 00
Sun Flower .....	.....	16	92	25	11	147	135	10	1	.....
Glendora	20	18	132	27	21	204	153	15	.....	.....
Hymers No. 2	6	18	123	37	16	190	124	12	.....	.....
Wilfred No. 1 .....	.....	16	93	47	20	179	183	12	1	.....

Showing Number of Miners, Machine Runners and Helpers, Etc.—Continued.

SULLIVAN COUNTY—Continued.

NAME OF MINE.	Pick Miners.	Machine Runners and Helpers.	Loaders.	Inside Day and Monthly Men.	Outside Day Men.	Total Employees.	Days Worked.	Mules Used.	Fatal Accidents.	Improvements.
Island No. 4.....	26	10	50	10	9	43	191	3	.....	.....
Mammoth Vein.....	.....	10	50	18	15	93	216	4	.....	3,889 51
Little Giant.....	.....	10	53	20	10	93	213	4	.....	.....
Gumming.....	42	10	13	20	10	95	159	8	.....	.....
La Blanche.....	.....	12	51	24	19	106	233	6	.....	.....
Citizens.....	11	4	19	4	6	44	240	.....	.....	.....
Blindles Creek No. 6.....	46	.....	.....	9	6	61	113	.....	2	.....
Mildred.....	14	10	18	8	6	53	190	.....	.....	.....
Virginia.....	26	18	85	15	12	145	114	.....	.....	.....
Superior.....	43	.....	.....	7	6	39	164	.....	.....	.....
Shirley Hill.....	.....	.....	.....	13	6	53	172	.....	.....	.....
St. Clair Hill No. 4.....	36	10	34	13	11	68	197	.....	.....	.....
Jackson No. 3.....	11	6	32	21	19	81	192	2	.....	.....
Kettle Creek.....	.....	12	85	33	19	160	117	10	.....	.....
Belance (New mine. No report.).....	.....	4	13	9	4	30	38	.....	.....	.....
Phoenix No. 4. (New mine. No report.).....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Union No. 1.....	6	6	13	7	8	40	41	2	1	.....
Total.....	509	276	1,379	660	395	3,219	4,694	226	8	\$6,986 32

VANDERBURGH COUNTY.

Diamond.....	37	.....	.....	7	7	51	281	4	.....	.....
First Avenue.....	23	.....	.....	5	6	33	224	3	.....	.....
Ingleside.....	25	.....	.....	6	5	44	231	3	.....	.....
Sunrise.....	65	4	4	20	10	95	141	14	.....	.....
Union.....	30	.....	.....	7	7	44	205	4	.....	.....
Unity.....	98	.....	.....	19	12	128	262	13	.....	.....
Total.....	274	4	4	64	47	393	1,314	40	.....	.....

VERMILLION COUNTY.

Bruliettes Creek No. 3.....	82	.....	24	9	115	195	14	.....	.....
Bruliettes Creek No. 5.....	163	.....	40	12	206	215	20	.....	.....
Cayuga.....	13	.....	4	2	19	223	3	.....	\$2,760 00
Crown Hill No. 1.....	157	.....	22	9	188	202	14	.....	3,959 00
Crown Hill No. 2.....	96	.....	12	7	115	194	9	1	7,354 90
Oak Hill.....	97	.....	28	11	136	152	12	.....	.....
Prince.....	168	.....	49	11	218	177	16	.....	208 13
Willow Grove.....	83	.....	14	7	104	159	8	1	1,444 60
Rhodes.....	91	.....	20	9	120	246	7	.....	.....
Riverside. (No report).....	.....	.....	.....	.....	.....	.....	.....	.....	1,663 65
Maple Valley No. 1.....	81	.....	15	7	103	158	7	.....	407 62
Maple Valley No. 2. (No report).....	.....	.....	.....	.....	.....	.....	.....	.....	1,150 00
Buckeye.....	40	.....	7	8	55	24	3	.....	.....
Total.....	1,051	.....	235	92	1,378	1,945	113	3	\$18,947 89

VIGO COUNTY.

Atherton.....	13	10	51	36	11	120	213	8	.....	.....
Brick Works.....	12	.....	.....	9	2	16	247	1	.....	\$400 00
Chicago No. 6.....	34	.....	.....	13	6	53	49	6	.....	.....
Diamond.....	133	.....	.....	40	12	185	210	17	2	.....
Peerless.....	174	.....	.....	19	9	102	168	9	.....	.....
Lawton.....	173	.....	.....	80	11	214	184	16	.....	.....
Union.....	42	.....	.....	13	11	68	69	6	.....	.....
Ehrlich.....	32	.....	.....	8	5	45	20	5	.....	.....
Grant No. 2.....	142	14	73	50	12	204	191	20	2	1,000 00
Glen Oak.....	29	.....	.....	50	16	181	215	25	.....	.....
Hector.....	43	.....	.....	15	9	67	187	7	.....	.....
Klondyke.....	15	.....	.....	13	10	100	185	10	1	.....
Miami No. 1.....	177	.....	.....	28	10	215	210	16	.....	.....
Park No. 10.....	.....	28	33	42	16	169	179	12	.....	.....
Redbird.....	41	.....	.....	10	5	56	237	4	.....	.....
Rosebud No. 2.....	172	.....	.....	80	11	213	129	12	.....	.....
Royal No. 1.....	102	.....	.....	23	13	138	173	9	.....	.....
Larimer.....	24	.....	.....	5	5	34	246	2	.....	.....
Broadhurst.....	58	.....	.....	11	8	77	220	6	.....	.....
Miami No. 2.....	80	.....	.....	15	7	102	170	6	.....	.....
Deep Vein.....	57	.....	.....	16	8	81	209	4	.....	.....
Greendale No. 1.....	54	.....	.....	10	5	69	240	4	.....	.....
Lost Creek.....	58	.....	.....	8	7	65	202	4	.....	.....
Sugar Creek.....	45	6	10	11	7	79	265	3	.....	.....
Ray No. 2.....	31	10	14	5	7	67	162	2	.....	.....
Miami No. 3.....	49	.....	.....	5	7	61	97	4	.....	.....
Forest Park. (New mine. No report.).....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Total.....	1,791	68	181	512	229	2,781	4,647	218	5	\$1,400 00

Showing Number of Miners, Machine Runners and Helpers, Etc.—Continued.

WARRICK COUNTY.

NAME OF MINE.	Pick Miners.	Machine Runners and Helpers.	Loaders.	Inside Day and Monthly Men.	Outside Day Men.	Total Employees.	Days Worked.	Mules Used.	Fatal Accidents.	Improvements.
Air Line.....	27	12	46	4	4	35	92	4	.....	\$1,318 55
Big Four.....	8	18	51	16	12	94	167	9	.....	.....
Big Vein No. 3.....	4	8	8	12	9	94	206	6	.....	510 00
Chandler.....	.....	4	10	3	6	25	60	2	.....	.....
De Forrest.....	.....	.....	.....	3	3	20	115	2	.....	.....
Star No. 1.....	40	12	50	9	8	57	195	6	.....	1,000 00
Electric.....	.....	.....	.....	17	12	91	243	6	.....	1,428 84
Star No. 2. (Barke).....	23	.....	.....	4	6	33	142	3	.....	.....
Total.....	102	54	165	68	60	449	1,220	40	.....	\$1,255 49
Grand Total.....	8,806	760	3,046	3,449	1,777	17,838	29,641	1,421	34	\$74,230 83

STRIKES AND OTHER LABOR CONDITIONS.

Numerous strikes of a local character have occurred throughout the State during the past year, which have affected only individual mines, with but three exceptions. These were of such short duration as to require no special mention.

One of the exceptions referred to was a strike of the drivers at the Indiana Bituminous Coal Company's Fairview Mine, located near Turner, in Clay County. The mule barns here are about one mile distant from the mine, and the drivers thought it was not a part of their day's work to bring the mules from these barns to the mine before working hours in the morning (7 o'clock). They refused to conform with the rules of the mine, and this resulted in a strike June 7th. Since that time the mine has not been in operation.

A strike occurred August 1st at the Coal Bluff Mining Company's Harrison No. 3 Mine. This was caused by the miners refusing the company permission to drive nothing but entries during the dull season. The reason given by the company for asking such permission was on account of the small demand for coal just at that time. They could not dispose of the product of the entire mine, and thought by driving nothing but narrow work they could increase the number of working places, thereby employing a larger force of miners and increasing the capacity of the mine when the market demanded it later in the season. Work was resumed after the mine had been idle about four weeks, but it was not learned on what terms a settlement was made.

On April 1st a strike occurred at the Knox Mine, located near Bicknell, in Knox County. The trouble here was caused by a difference between the operators and miners as to the time when shot firing should begin. Prior to this the time for firing shots had been 3:15 o'clock p. m., but as a new contract took effect on the above date, the company insisted on 3:30 as firing time. The miners demanded a continuance of the previous conditions, and after an idleness of five months the company conceded their demand and operations were again resumed at the mine.

The national joint convention of operators and United Mine Workers of America was held in Indianapolis during the month of February, at which time a contract was agreed upon whereby

the miners accepted a reduction of 5 cents per ton on the price paid for pick mining and a proportionate reduction in the wages of machine miners and all other labor in and around the mines. This reduction took effect on April 1st, and the contract covers a period of two years, extending from April 1, 1904, to March 31, 1906. Considerable dissatisfaction on the part of the miners was expressed at the time the settlement was made, but after the situation had been thoroughly explained to them and matters made plain, the wisdom and energy displayed by the national and State officers in securing so favorable a contract in the face of a falling market was commended in every part of the State, and at the State conventions held in Terre Haute and Brazil in the following month of March the contract was ratified without hesitation.

We give herewith copies of the Terre Haute and Brazil agreements, made by the miners of District 11, representing the bituminous field, and the miners of District 8, representing the block coal field:

TERRE HAUTE AGREEMENT.

APRIL 1, 1903, TO MARCH 31, 1904.

Pursuant to an agreement made between the coal operators and the United Mine Workers of America of Illinois, Indiana, Ohio and Pennsylvania, made at Indianapolis, Indiana, March 21, 1904, the price of mining for bituminous coal in the State of Indiana shall be 85 cents per ton of 2,000 pounds for screened lump coal, made over a standard screen, and 52 cents per ton of 2,000 pounds for run-of-mine. That further details in the scale of prices for pick and machine mining in the State of Indiana for one year, beginning April 1, 1904, shall be as follows:

The standard height of coal in Indiana shall be 3 feet 6 inches, excepting in mines already opened, where the standard height shall be 3 feet 3 inches. All coal less than 3 feet 3 inches in thickness and over 2 feet 9 inches, the price shall be 93 cents per ton for screened lump coal, and 57 cents per ton for mine run coal. All coal less than 2 feet 9 inches and down to 2 feet 6 inches, the price shall be \$1.01 per ton for screened lump coal and 62 cents per ton for mine-run coal.

Narrow entries 7 to 9 feet wide, \$1.76½ per yard.

Wide entries 12 feet wide, \$1.10 per yard.

Wide entries shall not be more than 13 feet nor less than 11 feet. In the event of a 10 or 11 foot entry being demanded by the operator, narrow entry prices shall be paid, if 14, 15, 16 or 17 foot entries are demanded the wide price shall be paid.

The right of the operators to drive an 18-foot room when necessary shall not be questioned.

BREAK THROUGHS.

Break throughs between entries shall be paid for at entry prices. Break throughs between rooms, when sheared or blocked, shall be paid for at entry prices, but no break throughs shall be driven without consent of the operators. Nothing herein shall interfere with the law governing break throughs.

ROOM TURNING.

Room turning, \$4.25. Room necks to be driven 12 feet in and widened at an angle of 45 degrees when so desired by the operator. Any distance in excess of above shall be paid for proportionately, but no room neck shall exceed 15 feet. When room necks are driven 12 feet wide, the price shall be $\frac{5}{8}$ of regular price, \$2.65%.

MACHINE MINING.

In entries 7 to 9 feet wide, \$1.26 $\frac{1}{2}$. In entries 12 feet wide, $\frac{5}{8}$ of price of narrow entries, or \$0.78%. Narrow work after punching machine shall be sheared when demanded by the operator. Narrow work after the chain machine must be done in a workmanlike manner.

BREAK THROUGHS.

Break throughs between entries, same as entry prices. Break throughs between rooms shall be paid for at the same price when similarly driven.

ROOM TURNING.

Room turning, \$3.18%. Room necks to be driven 12 feet in and widened at an angle of 45 degrees when so desired by operators. Any distance in excess of above shall be paid for proportionately, but no room neck shall exceed 15 feet. When room necks are driven 12 feet wide, prices shall be $\frac{5}{8}$ of regular price, or \$1.98 $\frac{1}{2}$.

DAY WORK FOR PUNCHING MACHINE.

Machine work, when paid for by the day, shall be: For machine runner, \$2.90 $\frac{1}{2}$; helper, \$2.42.

DAY WORK, CHAIN OR CUTTER BAR MACHINE.

When paid for by the day, shall be: For machine runner, \$2.84 $\frac{1}{4}$; helper, \$2.84 $\frac{1}{4}$. Day work for machines shall apply only to opening new mines and defective work, such as horse backs, etc.

PRICE PER TON FOR MACHINE MINING FOR PUNCHING MACHINE.

Vandalla track and north thereof:

Screened Lump.—Runner, 10 $\frac{3}{4}$ cents; helper, 9 $\frac{3}{4}$ cents; loading, shooting and timbering, 46 $\frac{1}{2}$ cents. Total, 67 cents,

Run of Mine.—Runner, 7 cents; helper, $6\frac{1}{2}$ cents; loading, shooting and timbering, $28\frac{1}{2}$ cents. Total, 42 cents.

South of Vandalia track:

Screened Lump.—Runner, $9\frac{3}{4}$ cents; helper, 8 13-20 cents; loading, shooting and timbering, 48 6-10 cents. Total, 67 cents.

Run of Mine.—Runner, 6 7-40 cents; helper, 5 27-40 cents; loading, shooting and timbering, 30 3-20 cents. Total, 42 cents.

FOR CHAIN MACHINE.

Screened Lump.—Runner, $5\frac{3}{4}$ cents; helper, $5\frac{3}{4}$ cents; loading, shooting and timbering, 52 cents. Total, $63\frac{1}{2}$ cents.

Run of Mine.—Runner, $3\frac{3}{8}$ cents; helper, $3\frac{3}{8}$ cents; loading, shooting and timbering, $32\frac{1}{4}$ cents. Total, $39\frac{1}{2}$ cents.

Machine shovels shall be furnished by the operators, but when replaced the old shovels must be returned, and in case of careless breaking or destruction, the helper shall pay for the shovel so destroyed.

BLACKSMITHING.

Price of blacksmithing shall be $1\frac{1}{4}$ cents on the dollar. Sharpening shall be done in workmanlike manner and men shall not have to wait for their tools.

DAY LABOR.

Inside day labor shall not be less than \$2.42 per day of eight hours, when men are employed. And for outside day labor on the north of the B. & O. S. W. the minimum price shall be \$1.91 $\frac{1}{4}$ per day. South of the B. & O. S. W. the price shall be 19 $\frac{1}{8}$ cents per hour.

All outside day laborers working at the mines, excepting weighmasters, flat trimmer and dumper, who shall be regarded strictly as company men, shall be recognized as members of the United Mine Workers of America, and present conditions and hours of labor shall prevail during the existence of this contract; and provided further, that in emergencies or in the absence of any regular employe the right of the operator to employ men not members of the United Mine Workers of America for outside day labor shall not be questioned. Any and all flat trimmers shall dock for dirty coal.

DEAD WORK.

1. It is agreed that the companies shall have the working places as dry as local conditions will permit, and said working places shall be in working condition at time of starting work in the morning. If any company shall fail to have said working places dry or reasonably so one hour after starting time two successive days, the company shall, if said failure is traceable to neglect or carelessness of the company's agent, give miner or miners so affected other work or pay him or them for time so lost.

2. The question of slate in or over the coal shall be and is regarded a local question to be taken up and adjusted by the methods provided in

the annual Terre Haute agreement for settlement of disputes: Provided, however, that established usages and prevailing conditions shall not be changed except in new mines where they have not been considered and adjusted.

3. Where bottom coal is excessively hard to take up, the operator shall have the option. If he demands that it be taken up he shall pay extra therefor. Provided, that where coal so ~~ft~~ shall exceed four inches in thickness it shall be taken up by the loaders and paid for by the machine men, but this shall not apply when caused by sulphur, boulders, rock or any unusual condition. And whenever there shall arise a dispute between any loader and boss, or committee and boss, as to whether the bottom coal in any room is "excessively hard" the company interested shall select a man who shall take up one-third of such bottom coal, and if by such test it requires more than forty minutes to take up all the bottom coal in such room, then the loader shall be paid at the rate of 30 cents per hour for such time so required in excess of forty minutes. This is to apply to the No. 4 vein of Linton coal.

GENERAL.

1. When the coal is paid for mine run, it shall be mined in as good condition as when paid for on a screened lump basis, and, when loaded on the miner's car, it shall, as nearly as possible, be free from slate, bone coal, or other impurities, and, if it can be shown that any miner persistently violates the letter or spirit of this clause, he shall be discharged. Persistently, as used in this clause, means three cars the first week and two cars in any succeeding week. Nor shall he load an undue proportion of fine coal in any one car, but shall see that the fine coal is mixed with the large coal in such a way as to make a fair quality of mine run coal. This provision for cleaning coal and penalty for failure also applies to screened lump coal.

2. The semi-monthly pay shall continue until the constitutionality of the law providing for weekly pay shall have been passed upon by the Supreme Courts of Indiana and of the United States.

3. The time of beginning work in the morning and the length of intermission at noon shall be considered a local question.

4. That the above scale is based upon an eight hour work day; that it is definitely understood that this shall mean eight hours work at the face, exclusive of the noon time, six days in the week, or forty-eight (48) hours in the week, and that no local ruling shall in any way deviate from this agreement, or impose conditions affecting the same, but any class of day labor may be paid at the option of the operator for the number of hours and fraction thereof actually worked at the hour rate, based on one-eighth of the scale rate per day; provided, that when men go into the mine in the morning they shall be entitled to two hours' pay whether the mine works or not, excepting in event of a mine being closed down by action of any member or members of the U. M. W. of A., the two hours' pay shall be forfeited.

REGARDING DRIVERS.

They shall take their mules to and from the stables, and the time required in so doing shall not include any part of the day's labor, their work beginning when they reach the change at which they receive empty cars, but in no case shall a driver's time be docked while he is waiting for such cars at the point named.

5. Inside day work may be done upon idle days, and in case of emergency on overtime.

6. It is agreed that if any difference arises between the operators and miners at any time, a settlement shall be arrived at without stopping the work. If the parties immediately affected can not reach an agreement themselves, the question shall be referred without delay to a board of arbitration constituted of two operators, selected by the operator interested, and two miners selected by the local union of the United Mine Workers of America involved. In the event of these four being unable to reach a decision, they shall select a fifth man, and the decision of the board so constituted shall be final, but no miner or operator directly interested in the differences shall be a member of such board. Nothing in the above shall be construed as excluding officers of the miners' or operators' associations, nor mine superintendents.

7. The duties of the mine committee shall be confined to the adjustment of disputes between the mine boss or superintendent and any of the members of the United Mine Workers of America, working in and around the mines, except as hereinafter set forth in Article No. 16. In case they fail to agree, they shall proceed to adjust the trouble by the selection of an arbitration board as provided in Article 6 of this agreement. The mine committee shall have no other authority, nor exercise any other control, nor in any way interfere with the operation of the mine, and, for violation of this agreement, the committee or any other member thereof or mine boss or superintendent, shall be discharged.

8. That under no circumstances will the operators recognize or treat with a mine committee or any representative of the United Mine Workers of America, during the suspension of work, contrary to this agreement.

9. The operator shall have the privilege of working a night shift for cutting coal with machines. All men so employed shall be paid 28 cents extra for each eight hours' work at night, in addition to the scale price per ton.

10. Work on driving entries and drawing pillars may be by double shift at the option of the operator.

11. This contract shall in no case be set aside because of any rules of any local union of the U. M. W. of A. Nor shall there be any rules made controlling or affecting the operation of the mines, nor shall any change be made in accepted rules without the operators and miners first consulting and agreeing thereto.

12. Coal may be dumped as slowly as the operator may find necessary to thoroughly screen it, even if the car is brought to a stop, but it shall not be dumped in such a way as to throw the coal over the car door or unnecessarily break it.

13. Any miner knowing his place to be unsafe, shall protect same

without delay and shall go into the mine for that purpose outside of regular hours and on idle days.

14. No restriction shall be placed on the amount of coal which machines may mine, nor on the number of cars that any miner may load in any specified time.

Men shall work double in wide entries at option of operator in developing the mine or for running entries for the purpose of increasing production.

Enough extra loaders shall be employed in each mine so that the full complement of loaders agreed upon to follow each machine shall be at work every day that the mine hoists coal.

Where three places are now given to two loaders the custom shall continue.

No more than three places for two men nor two places for one man shall be allowed. In mines where the coal averages 6 feet high or over, rooms 30 feet wide or over equipped with two tracks shall be considered double places, and two loaders may be limited to two such places.

In Sullivan County where men work double in two rooms 25 to 30 feet wide, with track up to the center, the custom shall continue.

Whenever a new mine is opened it shall be governed by the same rules existing in other contiguous mines in the same vein of coal.

15. The price of powder per keg shall be \$1.75. The miners agree to purchase the powder from their operators, provided it is furnished of standard grade and quality, that to be determined by the operators and expert miners jointly where there is a difference.

16. Engineers shall be paid the present rate of wages, minus 5.55 per cent. Eight hours shall constitute a day's work. But the engineers shall, outside of regular hours, hoist and lower the men, and in addition shall perform all the duties which necessarily and usually pertain and belong to an engineer's position, and shall not receive any extra pay therefor. It is agreed further that no hoisting engineer shall be subjected to the interference or dictates of the mine committee nor the local unions, but all the differences between the engineer and his employer shall be adjusted by the officers of the U. M. W. of A. and employer interested.

17. The prices now paid firemen and blacksmiths, together with the present condition of employment and hours of labor, shall continue during the existence of this contract. Less 5.55 per cent.

18. It is further agreed that the operators shall offer no objection to the check-off for the check-weighman and for dues for the U. M. W. of A., provided, that no check-off shall be made against any person until he shall have first given his consent in writing to his employer. This applies to all day work as well as miners.

SHOT FIRERS.

Present conditions as to shot firers shall continue until a commission composed of one miner, to be selected by the United Mine Workers of America of District No. 11, one operator, to be selected by the Bituminous Coal Operators' Association of Indiana, and Prof. Robert Thurston, of Cornell College, an expert engineer shall be appointed.

Such commission shall, as soon as possible, examine the so-called dan-

gerous pick mines in the State of Indiana, and decide whether or not it is necessary to employ shot firers in any of said mines, on account of gas, dust or other causes beyond the control of either miners or operators, the present methods of mining not to be considered as being beyond control.

If a majority of such commission shall decide that it is necessary that shot firers be employed in any mine and shall sign a report to that effect, then shot firers may be employed by the miners in such mine, who shall pay them for their services, and such shot firers shall be wholly in the employ of the miners and in no manner whatever to be the agents, servants or employees of the owners, operators or managers of the mine.

The owner or operator of any mine where the commission decides that it is necessary that shot firers be employed and where they are so employed by the miners, shall pay to the local union an amount of money equivalent to one-fourth ($\frac{1}{4}$) cent per ton of mine run, or two-fifths ($\frac{2}{5}$) cent per ton of screened lump coal of the output of said mine.

It being agreed and understood that such payment to the local union shall not directly or indirectly be considered as or construed to be a payment by the owner or operator of any part or portion of the services rendered by shot firers for the miners.

It being further expressly agreed and understood that in any mine where shot firers are employed that the relation of master and servant shall exist wholly between the miners and the shot firers, and that such relation shall not obtain as between the owner or operator of the mine and the shot firers.

The expenses of such commission shall be borne equally by the United Mine Workers of America of District No. 11, and the Bituminous Coal Operators' Association of Indiana, except that the Operators' Association shall alone bear the expenses occasioned by the appointment and services of the expert engineer.

In behalf of the Indiana Bituminous Coal Operators' Association:

J. C. KOLSEM, President.

P. H. PENNA, Secretary.

United Mine Workers of America, District No. 11:

GEO. HARGRAVE, President.

J. H. KENNEDY, Secretary.

AGREEMENT BETWEEN THE BLOCK COAL OPERATORS AND
THE UNITED MINE WORKERS OF AMERICA, DISTRICT
No. 8, FROM APRIL 1, 1904. TO APRIL 1, 1906.

CONTRACT.

PICK MINING SCALE FOR 1904-1906.

Contract between the operators, miners and day laborers of the Brazil Block Coal District, from April 1, 1904, to April 1, 1906.

1. Entered into this first day of April, 1904, between the Operators' Scale Committee of the Block Coal District, and the Executive Board of the United Mine Workers of America, representing District No. 8.

2. Pursuant to a contract made between the Coal Operators and the

BRAZIL AGREEMENT.

United Mine Workers of America, of Indiana, Illinois, Ohio
sylvania, made at Indianapolis, Ind., March 21, 1904.

3. The price for mining screened block coal in the Block Co
of Indiana shall be ninety-five (95) cents per ton of 2,000 lbs
understood also that the price for digging unscreened coal s
equivalent of the price paid for screened coal.

4. That further details in the scale prices for pick mining in
Coal District shall be as follows:

5. The payment for low coal shall be upon the following sc

6. For all coal two feet ten inches, and under three feet one
dollar (\$1.00) per ton.

7. For all coal under two feet ten inches, one dollar and
(\$1.05) per ton.

8. The price of yardage shall be as follows:

Single yardage in coal 3 ft. 1 in. or over.....	\$0
Double yardage in coal 3 ft. 1 in. or over.....	1
Gob entries in coal 3 ft. 1 in. or over.....	1
Gob entries in coal 3 ft. 1 in. or over, without brushing.	
Single yardage in coal 2 ft. 10 in. and under 3 ft. 1 in...	1
Double yardage in coal 2 ft. 10 in. and under 3 ft. 1 in...	2
Gob entries in coal 2 ft. 10 in. and under 3 ft. 1 in.....	1
Gob entries in coal 2 ft. 10 in. and under 3 ft. 1 in., with- out brushing	
Single yardage in coal below 2 ft. 10 in.....	1
Double yardage in coal below 2 ft. 10 in.....	2
Gob entries in coal below 2 ft. 10 in.....	1
Gob entries in coal below 2 ft. 10 in., without brushing.	

All entries to be driven, when required by the operator, 5
the clear in height, and the miners agree to gob the dirt, when
required to take it more than the distance of six rooms back
last breakthrough, and when the dirt is hauled by a mule,
miners agree to unload the same at a distance of not more th
rooms back from the last breakthrough, from the face of th
This agreement shall apply to all the block coal mines in the B
District, with the exception of the present No. 1 and No. 2 Super
of the Zellar, McClellan & Co., and in these two mines the sa
tions shall continue as were in force during the year just end
The miners shall continue to gob the breakthroughs. Twenty-f
per yard shall be paid for all double yardage, when the same is
double shift, and 12½ cents per yard for all single yardage, w
same is worked double shift. Work on driving entries and drawin
may be by double shift at the option of the operator.

9. Inside day scale:

Track layers	\$2 4
Track layers' helpers.....	2 4
Trappers	1 0
Bottom cagers	2 4
Drivers	2 4
Trip riders	2 4
Water haulers	2 4

Timberman, where such are employed.....	2 42
Pipemen, for compressed air plants.....	2 37½
All other inside day labor.....	2 42
Blacksmiths	2 69.36
All outside day labor shall receive.....	1 91¼

10. The firemen and night pumpers shall be paid at the rate of twenty-three and nine-tenths (23 9-10) cents per hour for their labor. The above wage is based on an eight (8) hour work day, but in the event the operator desires it, the firemen and night pumpers are to work overtime to the extent of not more than two hours, in any one day or shift. However, it is understood that in the event of an emergency the firemen and night pumpers will not limit their time, but continue working until such emergency is past.

11. The firemen and night pumpers shall be subject to the same rules and regulations as the top men, and be in their class, and may be laid off in case the mine shall work only parts of days, and the work of the firemen and the top men, may be interchanged if it is found to be to the interest of the employer so to do, for example: Where the work can be performed by one man, the firing and any other work about the top shall be done by any one of the top men selected.

12. Where a miner is working a deficient place, and is being paid by the day, his pay shall be \$2.42 per day, and if he uses his own tools during such time, he shall be paid ten cents per day for the use of same. The operator shall have the option of furnishing the tools for any such work.

13. The price of blacksmithing shall be 1½ cents on the dollar.

14. Semi-monthly pay shall continue until the constitutionality of the law providing for weekly pay, shall have been passed upon by the Supreme Courts of Indiana, and of the United States.

15. The miner shall not be compelled to load his coal more than six feet from the face, at the beginning time.

16. Inside day work may be done upon idle days, and in the case of emergency on overtime.

17. The hour to begin work in the morning shall be seven (7) a. m., with thirty minutes stop for dinner, and begin shooting at 3:30 o'clock p. m., from April 1, 1904 and 1905, to October 1, 1904 and 1905, and from October 1, 1904 and 1905, to April 1, 1905 and 1906, the mines shall start at 7:30 a. m. with thirty minutes stop for dinner, and begin shooting at 4:00 p. m., and that no shooting shall be done at the mine except by mutual consent between the bank boss and the bank committee, and in the event that the mine is to work a half day, it shall be the duty of the mine boss to notify the bank committee of the fact.

18. That eight hours a day means eight hours' work in the mine at the usual working places, for all classes of inside workmen. This shall be exclusive of the time required in reaching said working places in the morning, and departing from the same at night.

19. The miners hereby agree to do all the propping in their rooms, except setting of props required to break the bottom in shooting the same, and if any props are loosened or displaced, thereby endangering the safety of the workmen, the miners agree to reset the same.

20. It is also agreed on the part of the operators not to require the miners to put down their own road, and bottom shooters may lay the road in the rooms when required.

21. Also, to give each miner as near as possible an equal turn of cars, and not allow any day hands to load coal on idle days.

22. No miner shall be discharged or discriminated against because of his refusal to do work by the day when called upon by the pit boss.

23. It is also agreed not to require miners to load or clean falls unless they are caused by some fault of the miner not properly timbering his working place, or his having shot or otherwise caused his timber to become insecure, in which case it will be the duty of the miner to put his place in good order again.

24. It is further agreed that if any difference arise between the operator and miner at any pit, settlement shall be arrived at without stopping of work. If the parties immediately affected can not reach an adjustment between themselves, the question shall be referred to the Executive Board of the United Mine Workers of America, representing District No. 8, and an equal number of operators, whose actions shall be final, but no miner nor operator interested in the differences shall be a member of said committee.

25. The duties of the mine committee shall be confined to the adjustment of disputes between the mine boss or superintendent and any of the members of the United Mine Workers of America, except the engineer, working in and around the mines.

26. Regarding Drivers: They shall take their mules to and from the stables, and the time required in so doing shall not include any part of the day's labor. Their work beginning when they reach the parting at which they receive empty cars, and in no case shall the drivers' time be docked while he is waiting for said cars at point named, but when the men go into the mine in the morning, they shall be entitled to two hours' pay, whether or not the mine works the full two hours, but after the first two hours, the men shall be paid for every hour thereafter, by the hour or for each hour's work, or fractional part thereof. If for any reason the regular routine of work can not be furnished inside labor for a portion of the first two hours, the operators may furnish other than the regular labor for the unexpired time.

27. That under no circumstances will the operators recognize or treat with a mine committee or any representative of the United Mine Workers of America, during the suspension of work contrary to this agreement.

28. The Block Coal District of Indiana may continue the use of the diamond bar screen, the screen to be seventy-two (72) feet superficial area, of uniform size, one and one-quarter ($1\frac{1}{4}$) inches between the bars, free from obstructions, and that such screen shall rest upon a sufficient number of bearings to hold the bars in proper position.

29. It is hereby further agreed that track layers may begin work on top before the usual time of holsting coal, in getting track material ready to send down on the cage, and that the time required in doing so, shall be a part of the eight hours' work.

30. In case of emergency work, the mine boss shall consult with the mine committee, and if they approve of the work being done on over-

time, the men engaged thereon shall not be required to lay off until their time is equalized with the others working in said mine.

31. The Crawford Coal Company in their mines at Center Point may continue to do the brushing in the entries where the coal is 3 feet 1 inch and under in thickness.

32. On and after April 1, 1904, until April 1, 1906, the scale of hoisting engineers throughout the Block Coal District, or District No. 8, shall be as follows: Where one engineer is employed, the compensation shall be seventy-nine dollars and sixty-eight and one-half cents (\$79.68½) per month. Where two engineers are required, the first engineer shall receive seventy-nine dollars and sixty-eight and one-half cents (\$79.68½) per month, the second sixty-nine dollars and six cents (\$69.06) per month, and when they change week about, seventy-four dollars and thirty-seven and one-fourth cents (\$74.37¼) per month.

33. It is agreed on the part of the engineers to be at their work in time to lower the men and mules, and remain a sufficient time after the regular working hour to hoist the men and mules from the mine. Also to keep up all repairs on the machinery, including pumps in the mine.

34. It is also mutually agreed that a licensed engineer shall be employed at all times when steam is required at the throttle: provided, however, that in all cases where the mine is not hoisting coal, or the machines are not operated, then, and in all such cases, the engineers are required to do their own firing, it being understood that this provision does not apply to any case where the work of the mine may be stopped in the midst of any one shift. Nor does it cover any case where the fireman is required to assist in the washing or cleaning out the boilers on Sunday.

35. It is also fully understood and agreed upon the part of the United Mine Workers of America, that the engineers will not under any circumstances allow affiliation with any labor organization to interfere with or prevent their being on duty at any and all times required by the operators, and that they will not suspend work in sympathy with any organization; and further, that they will during the continuance of this contract at all times fully protect all the company's property under their care, and that they will operate fans and pumps, and lower or hoist such men or supplies as may be required to protect the company's property, and any and all coal that may be required to keep up steam at the company's plant. But it is understood that the operators will not ask them during this period to hoist any coal produced by non-union labor for sale on the market.

36. No engineer shall lay off or exchange shifts without the consent of the operators.

37. It is also agreed that in case of sickness or unexpected absence of the engineer any other engineer or engineers shall perform his duty; and if desired by them his wages for time so absent shall revert to the engineer performing such duty.

38. It is further agreed no hoisting engineer shall be subject to the interference or dictation of the mine committee nor the local unions, but all differences between the engineer and his employer shall be adjusted by the officers of the United Mine Workers of America and employer interested.

39. It is also agreed upon the part of the operators that they will enforce a rule forbidding the entering of the engine room by loafers and disinterested parties, and that they will have cards printed and placed in conspicuous places to this effect.

40. This contract is entered into in good faith by both parties, and there is to be no deviation from it by the operators, miners, laborers or any local unions.

Committee on behalf of the Operators for the Block Coal District:

JAS. H. McCLELLAND.
M. H. JOHNSON.
W. E. EPPERT.
WM. M. ZELLER.
A. H. ZIMMERMAN.
HUGH MASON.
JAS. J. BUCKLIN.

Executive Committee, District No. 8, United Mine Workers of America, for Block Coal Miners:

WM. HOUSTON, Pres. Dist. 8.
JOHN S. BENNETT, Vice-Pres.

WM. TREAGER, Secy.-Treas.
THOS. SLATER.
ROBERT GIVENS.

CONTRACT.

MACHINE MINING SCALE FOR 1904-1906.

Contract between the Machine Operators of the Block Coal District and the Executive Board, District No. 8, United Mine Workers of America, governing prices and conditions of mining in Machine Mines Block Coal District, from April 1, 1904, to April 1, 1906.

1. Entered into this first day of April, 1904, between the Operators Machine Mines of the Block Coal District and the Executive Board of the United Mine Workers of America, representing District No. 8.

2. Pursuant to a contract made between the Coal Operators and the United Mine Workers of America of Illinois, Indiana, Ohio and Pennsylvania, made at Indianapolis, March 21, 1904.

3. The price for loading, shooting, timbering, taking care of all draw slate that is four (4) inches and under in thickness, in rooms and entries, shall be forty-nine and three-fourths (49¾) cents per ton.

Price for entry driving, 6 to 9 feet wide, forty-nine and three-fourths (49¾) cents per yard.

Price for entry driving, 9 to 12 feet wide, thirty and three-fourths (30¾) cents per yard.

The loader agrees to keep the bug dust and draw slate back 14 feet from the working face.

All entries more than twelve feet in width shall be paid same as rooms.

Machine runners and helpers to be paid twenty-three and three-fourths (23¾) cents per ton, and when working by the day, machine runner to be paid \$2.86½ per day; helpers, \$2.55 per day; motormen to receive \$2.86½ per day.

Entry driving, 6 to 9 feet wide, machine runner to be paid twenty-three and three-fourths (23¾) cents per yard.

Entry driving, 9 to 12 feet wide, machine runner to be paid fifteen (15) cents per yard.

It is further agreed that where there is not sufficient room to gob the bug dust and draw slate, the loader will load it in the bank cars, and the company will unload it.

It is understood that there shall be nothing paid for room turning or low coal, and there shall be nothing charged for blacksmithing.

There shall be no discrimination against any employees.

That the system of loading coal in machine mines be on the following basis, to wit:

1. That one man shall have the right to two places where he can take care of the same.
2. That two men shall have the right to three places where they can take care of the same.
3. All others one place.

When a man is off work more than one day, the mine boss shall have the right to put a man in the places if it is necessary, providing the man leaves the places in the same condition, as near as possible, as he found them.

The Block Coal District of Indiana may continue the use of the diamond bar screen, the screen to be seventy-two (72) feet superficial area, of uniform size, one and one-quarter (1¼) inches between the bars, free from obstructions, and that such screen shall rest upon a sufficient number of bearings to hold the bars in proper position.

This agreement to become a part of the agreement entered into on the 1st day of April, 1904, between the Operators' Scale Committee of the Block Coal District, and the Executive Board of the United Mine Workers of America, representing District No. 8.

On behalf of the Machine Operators of the Block Coal District:

OTTER CREEK COAL CO.,
A. H. ZIMMERMAN, Supt.

BRAZIL BLOCK COAL CO.,
JAS. H. McCLELLAND, President.

On behalf of the Executive Board, District No. 8, United Mine Workers of America:

WM. HOUSTON, President.
JOHN S. BENNETT, Vice-Pres.
WM. TREAGER, Secy.-Treas.
THOS SLATER.
ROBERT GIVENS.

TABLE

Showing by Counties the Number of Miners, Number of Inside Day and Monthly Men, Number of Outside Day and Monthly Men Employed; Total Wages Earned by Same and Average Wages Earned Per Employee, Both for the Block and Bituminous Mines.

BLOCK COAL MINES.

COUNTY.	Number of Miners.	Total Wages of Miners.	Average Wages Per Miner.	Number of Inside Day and Monthly Men.	Total Wages of Inside Day and Monthly Men.	Average Earnings Day and Monthly Men.	Outside Employees.	Total Wages Outside Employees.	Average Earnings Outside Employees.
Clay.....	950	\$345,411 28	\$363 58	247	\$155,807 83	\$590 31	143	\$8,205 80	\$570 95
Parke.....	883	304,479 48	445 79	197	138,588 70	698 42	71	58,112 24	818 48

BITUMINOUS MINES.

Clay.....	829	\$338,875 83	\$408 77	223	\$144,949 17	\$649 98	110	\$77,284 91	\$702 59
Davies.....	271	97,715 02	360 57	63	30,398 12	482 50	33	19,384 98	587 13
Fountain.....	71	41,285 30	581 20	17	11,894 58	702 03	13	7,192 44	553 26
Gibson.....	109	64,358 05	498 69	33	21,714 43	658 01	21	14,009 76	667 13
Greene.....	2,301	1,273,133 85	553 29	726	465,057 63	641 95	277	246,113 73	886 71
Knox.....	250	87,275 24	349 10	60	24,193 82	403 23	58	20,463 74	356 27
Parke.....	645	309,182 10	471 64	177	128,562 13	726 34	79	64,387 39	688 51
Perry.....	16	5,303 11	331 31	3	1,387 52	462 50	3	1,268 78	422 83
Pike.....	629	197,213 30	311 94	164	68,069 26	415 05	146	39,423 67	294 46
Sullivan.....	2,164	\$22,099 13	\$79 88	660	\$79,449 07	\$75 22	395	255,506 19	\$397 46
Vanderburgh.....	283	148,985 65	528 31	64	46,801 82	731 27	47	39,123 71	832 41

TABLE.

MACHINE MINING.

Exhibiting by Counties the Names of Mines in Which Machine Mining is Carried On; Geological Number of Coal Seam Mined; Average Number and Kind of Machines in Use; Number of Miners Employed, Total Tons of Coal Produced, Average Tons Per Miner and Average Tons Per Machine Produced and the Number of Days the Machines Were Operated.

BLOCK COAL MINES.

CLAY COUNTY.

MINE.	KINDS OF MACHINES USED.			Number of Days Mine Was Operated.	Total Tons Produced.	Number of Miners Employed.	Average Tons Per Miner.	Average Tons Per Machine.
	Geological Number of Seam.	Electric Chain.	Compressed Air Puncher.					
Brasil Block No. 1.....	IV	2	.....	285	8,707	12	725	4,351
Brasil Block No. 8.....	III	3	.....	193	12,933	20	648	4,311
Diamond No. 5.....	IV	1	.....	60	3,319	11	340	3,349
Gart No. 10.....	III	3	.....	52	4,864	17	288	2,432
Total general average.....	.....	9	.....	590	29,853	60	497	3,317

PARKE COUNTY.

Brasil Block No. 12.....	IV	6	.....	203	26,308	38	694	4,884
Mary.....	III	7	.....	112	30,344	50	606	4,334
Total general average.....	.....	13	.....	345	56,642	88	644	4,357

BITUMINOUS MINES.

CLAY COUNTY.

Gifford No. 1.....	III?	4	.....	170	5,345	18	291	1,336
Gifford No. 2.....	III?	3	.....	150	10,600	24	733	9,533
Lewis.....	V	.....	5	137	35,452	40	896	7,090
Vivian No. 4.....	III	4	.....	215	18,729	25	748	4,682
Vivian No. 5.....	IV	3	.....	203	16,450	27	609	5,483
Island Valley No. 4.....	IV	4	.....	97	27,776	28	992	6,669
Gold Knob.....	III?	3	.....	131	15,083	28	539	5,027
Total general average.....	.....	21	5	1,103	120,435	190	633	5,785

MACHINE MINING—Continued.

GREENE COUNTY.

MINE.	KINDS OF MACHINES USED.			Number of Days Mine Was Operated.	Total Tons Produced.	Number of Miners Employed.	Average Tons Per Miner.	Average Tons Per Machine.
	Geological Number of Seam.	Electric Chain.	Compressed Air Puncher.					
Twin	IV-V	4	*	*	80,993	60	1,331	14,416
Black Creek	IV	5	..	146	72,801	70	1,040	14,560
Island No. 1	IV	..	..	204	52,523	38	1,431	8,784
Island No. 2	IV	..	6	172	81,251	68	1,231	5,803
Gilmour	IV	8	..	144	98,108	112	876	12,263
Hoosier No. 1	IV	3	..	215	43,248	32	1,331	14,416
Hoosier No. 2	V	..	..	40	11,535	20	576	5,767
Midland	III	6	..	116	54,174	62	837	9,029
Island Valley No. 2	V	..	4	137	13,469	24	799	4,317
Summit No. 2	IV	9	..	186	98,242	120	818	10,915
Glenburn	IV	5	..	174	56,662	66	858	11,332
Tower Hill	III	..	..	148	44,794	51	878	8,368
Green Valley	IV	9	..	135	118,833	117	972	12,848
Lattas Creek No. 1	IV	..	..	211	184,132	118	1,560	20,459
Atlas No. 1	IV	8	..	122	128,782	108	1,192	16,997
Atlas No. 2	IV	3	..	119	5,820	20	291	1,940
Letsinger	IV	4	*	..	9,252	28	330	2,313
North Western	IV	5	..	160	80,246	80	1,003	16,046
Total general average		85	34	2,429	1,234,871	1,190	1,037	14,529

*Not reported.

KNOX COUNTY.

Enterprise	VI	..	4	53	2,859	12	238	712
Pine Knot	VI	*	..	*	*	*	*	*
Total general average .....		..	4	53	2,859	12	238	712

*New mine, tonnage not reported.

PARKE COUNTY.

Lyford No. 1	VI	6	..	195	59,177	53	1,110	9,862
Parke No. 11	VI	..	11	178	62,569	54	1,168	5,687
Mecca No. 3	III	4	..	189	54,966	39	1,438	13,741
Total general average		10	11	562	176,702	146	1,217	8,414

SULLIVAN COUNTY.

Bunker Hill	VI	3	..	207	34,426	29	1,187	11,442
Caladonia	VI	12	..	222	85,228	79	1,078	7,102
Dugger	VI	*	..	*	*	*	*	*
Green Hill	VI	3	..	130	23,975	41	658	8,991
Hymers No. 1	III?	7	..	46	43,823	118	371	6,260
New Linton	VI	3	..	231	30,973	20	1,522	10,324
Jackson Hill No. 2	VI	18	..	171	126,993	125	1,015	7,055
Phoenix Nos. 1 and 3	V	..	4	90	32,672	20	1,655	8,084
Shelburn	VI	2	..	108	15,902	17	935	7,951

MACHINE MINING—Continued.

SULLIVAN COUNTY—Continued.

MINE.	KINDS OF MACHINES USED.			Number of Days Mine Was Operated.	Total Tons Produced.	Number of Miners Employed.	Average Tons Per Miner.	Average Tons Per Machine.
	Geological Number of Seam.	Electric Chain.	Compressed Air Pumper.					
Star City.....	VI	6	.....	147	69,212	74	935	11,537
Virginia.....	VI	8	.....	179	139,459	108	3,143	17,307
Sun Flower.....	VI	10	.....	158	128,592	143	912	12,859
Glendoria.....	V	9	.....	190	154,530	141	1,096	17,170
Hymers No. 2.....	VI	8	.....	183	132,005	112	1,179	16,500
Wilfred No. 1.....	VI	.....	*	.....	.....	.....	.....	.....
Reliance.....	VI	5	.....	93	58,950	80	962	11,790
Mammoth Vein.....	VI	5	.....	213	67,780	63	1,075	13,550
Little Giant.....	VII	.....	5	159	13,932	23	605	2,786
Cummins.....	VI	6	.....	233	91,265	63	1,448	15,210
La Blanche.....	VI	5	.....	107	19,185	44	236	3,937
St. Clair.....	VI	.....	3	128	2,780	18	154	923
Jackson Hill No. 4.....	VI	6	.....	117	40,701	97	417	6,781
Hymers No. 3.....	VI	2	.....	38	960	17	56	490
Kettle Creek.....	VI	5	.....	190	37,925	28	1,454	7,645
Mildred.....	VI	.....	*	.....	.....	.....	.....	.....
Phoenix No. 4.....	VI	.....	*	.....	.....	.....	.....	.....
Union No. 1.....	VI	.....	*	.....	.....	.....	.....	.....
Citizens.....	VI	2	.....	240	8,843	23	384	4,421
Total general average.....	.....	125	12	3,580	1,363,111	1,463	931	10,940

*Not reported.

VANDERBURGH COUNTY.

Ingleside.....	V	.....	2	44	1,636	8	204	618
Sunnyside.....	V	.....	.....	.....	.....	.....	.....	.....
Total general average.....	.....	.....	2	44	1,636	8	204	618

*Machines taken out.

VIGO COUNTY.

Atherton.....	VI	6	.....	213	90,088	61	1,640	15,014
Glen Oak.....	VI	7	.....	215	101,587	87	1,167	14,512
Parke No. 10.....	VI	.....	14	179	113,269	51	2,219	8,085
Sugar Creek.....	VI	5	.....	70	3,796	16	236	758
Ray No. 2.....	VI	.....	5	38	10,484	24	436	2,096
Forrest Park.....	VI	4	.....	.....	.....	8	.....	.....
Total general average.....	.....	22	19	715	319,224	267	1,195	7,785

*Not reported.

WARRICK COUNTY.

Big Four.....	V	.....	6	167	62,705	58	1,081	10,450
Big Vein No. 3.....	V	.....	9	206	94,566	69	1,371	10,507
De Forrest.....	V	.....	2	115	11,463	14	818	5,731
Electric.....	V	6	.....	243	97,442	62	1,571	16,240
Total general average.....	.....	6	17	731	266,176	203	1,311	11,138

TABLE

Showing Price Paid Per Ton for Pick and Machine Mining, Inside Day Labor, Total Number of Employees, Total Tons of Coal Produced, Total Wages Paid Employees, Wages Earned Per Year Per Employee and Per Cent. of Gain or Loss in Price Per Ton for Each Year from 1890 to 1904, Inclusive.

YEAR.	BLOCK MINING.				BITUMINOUS MINING.				Total Number of Em- ployes.	Total Tons of Coal Pro- duced.	Total Wages Paid Em- ployes.	Wages Earned per Year per Employee.	Per Cent. Gain in Price per Ton Over in Price per Year.	Per Cent. Loss in Price per Ton Under in Price per Year.
	Price Paid for Pick Mining Borenead Coal.	Price Paid for Chain Machine Mining Borenead Coal.	Price Paid for Pick Mining Borenead Coal.	Price Paid for Chain Machine Run Coal.	Price Paid for Punching Machine Mining Coal.	Wages Paid Inside Day Labor.								
1890	75	\$0	70	90	30	34%	9	3,791,211	81,852,500 00	824 93	15	7 1/2		
1891	75	75	70	70	34%	1 87%	9	3,619,600	1,750,000 00	246 08	29 1/2	5 1/2		
1892	75	75	70	70	34%	1 87%	9	4,038,471	1,600,000 00	200 40	29 1/2	15		
1893	75	75	70	70	34%	1 87%	9	4,338,867	1,600,000 00	200 40	29 1/2	15		
1894	75	75	65	65	34%	1 87%	9	4,202,084	1,600,000 00	200 40	29 1/2	15		
1895	70	70	60	60	34%	1 87%	9	4,038,124	1,600,000 00	200 40	29 1/2	15		
1896	70	70	60	60	34%	1 87%	9	4,038,100	1,600,000 00	200 40	29 1/2	15		
1897	61	51	51	51	30	1 71%	9	5,140,320	2,813,543 36	317 73	21 1/2	7 1/2		
1898	76	\$0 57	66	66	30	1 71%	9	5,898,713	2,813,543 36	317 73	21 1/2	7 1/2		
1899	76	66	66	66	30	1 71%	9	6,235,063	2,813,543 36	317 73	21 1/2	7 1/2		
1900	80	66	66	66	30	1 71%	9	7,019,203	2,813,543 36	317 73	21 1/2	7 1/2		
1901	80	66	66	66	30	1 71%	9	8,768,197	2,813,543 36	317 73	21 1/2	7 1/2		
1902	90	66	66	66	30	1 71%	9	9,149,672 12	2,813,543 36	317 73	21 1/2	7 1/2		
1903	1 00	75 1/2	75 1/2	75 1/2	45	2 36	9	9,992,553	9,149,672 12	608 61	12 1/2	12 1/2		
1904	95	75 1/2	75 1/2	75 1/2	42	2 42	9	9,872,404	9,160,404 38	525 63	12 1/2	12 1/2		

* Not reported.

Above prices are taken from the yearly contracts made between the operators and miners, and only from mines where organized labor was employed. The per cent. of increase and decrease is based on pick mining. Prior to 1888 chain machine mining was done either by the day or by the cut, hence no scale of prices per ton was obtainable.

EXAMINATIONS.

Examinations of applicants for certificates of competency to serve as Mine Boss, Fire Boss and Hoisting Engineer were held at Terre Haute March 15, 16 and 17; and August 25, 26 and 27.

The examinations were written and partly oral. The following table gives the names and addresses of those receiving certificates, also the number of the certificate:

MINE BOSS EXAMINATION HELD MARCH 15, 16 and 17, 1904.

<i>Name.</i>	<i>Address.</i>	<i>No. of Certificate.</i>
William Dempsey.....	Sullivan.....	35
Jacob C. Eck.....	Hymers.....	12
William R. Hilgedick.....	Linton.....	4
Harry Evans.....	Terre Haute.....	24
J. Willard Wacker.....	Clinton.....	23
James W. Templeton.....	Linton.....	17
Bert McClanahan.....	Hymers.....	1
John Watterson.....	Coal Bluff.....	59
John Johnson.....	Coal Bluff.....	16
Robert Monkhouse, Jr.....	Coal Bluff.....	90
A. T. Potter.....	Linton.....	10
C. L. Board.....	Linton.....	3
Lon Shaw.....	Sullivan.....	9
J. A. Richardson.....	Farmersburg.....	2
Charles Wilson.....	Seeleyville.....	..
James W. Meredith.....	Linton.....	5
James Gregory.....	Terre Haute.....	71
Harry Milburn.....	Lyford.....	22
Ephraim McGranhan.....	Brazil.....	6
Thomas Watkins.....	Brazil.....	7
William B. Tolson.....	Washington.....	25
W. H. Jackson.....	Sullivan.....	73
Benj. F. Whittington.....	Diamond.....	66
Frank Friend.....	Clay City.....	8
Dayton Ferris.....	Coal Bluff.....	..
Benj. R. Barnett.....	Brazil.....	74

HOISTING ENGINEER EXAMINATION, MARCH 15, 16 and 17, 1904.

<i>Name.</i>	<i>Address.</i>	<i>No. of Certificate.</i>
Jackson Wyeth.....	Terre Haute.....	31
Irwin D. Johnson.....	Edwards.....	77
Ed. Williams.....	Washington.....	20
Frank Garlinghouse.....	Clinton.....	78
Olney White.....	Dugger.....	41
C. B. Rouse.....	Sullivan.....	38
W. A. Heaton.....	Rosedale.....	57
W. E. Eslinger.....	Shelburn.....	27
George W. Chambers.....	Clinton.....	29
W. G. Woods.....	Terre Haute.....	37
T. N. Jean.....	Linton.....	34
William Sutton.....	.....	36
Hubert Parr.....	Fontanet.....	96
John O. White.....	Bridgeton.....	52
C. A. Dillahunty.....	Farmersburg.....	47
John W. Cable.....	Shelburn.....	51

<i>Name.</i>	<i>Address.</i>	<i>No. of Certificate.</i>
W. A. Pope.....	Linton.....	35
Louis Lyday.....	Linton.....	36
M. L. Ramsford.....	Shelburn.....	68
Lawrence T. Hicks.....	Evansville.....	46
Howard S. Brown.....	Bridgeton.....	53
Henry P. Ward.....	Edwardsport.....	55
Henry Miller.....	Dugger.....	39
John D. Britton.....	Brazil.....	91

MINE BOSS EXAMINATION HELD AUGUST 25, 26 AND 27, 1904—Continued.

<i>Name.</i>	<i>Addresses.</i>	<i>No. of Certificate.</i>
W. F. Asbell.....	Dugger.....	43
Adam Purvis.....	Rosedale.....	39
John Randall.....	Linton.....	38
Wm. Babbitt.....	Sullivan.....	37
Harry Antibus.....	Linton.....	36
Arthur Thompson.....	W. Terre Haute.....	34
Thomas Harrop.....	Dugger.....	33
Murray Bledsoe.....	Caledonia.....	32
Samuel Bradshaw.....	Perth.....	28
Wm. C. Keller.....	Columbus.....	27
Jas. J. Johnson.....	Fontanet.....	66
John Thomas.....	Midland.....	105
M. A. Pell.....	Brazil.....	90
John Holden.....	Diamond.....	82
Stephen Adams.....	Linton.....	67
John Bennie.....	Linton.....	48
Frank Morris.....	Shelburn.....	29
H. S. Bonham.....	Linton.....	47
Edward Cole.....	Sullivan.....	26
Louis Dablemont.....	Linton.....	30
M. M. Sweeding.....	Brazil.....	112
Geo. Sildamridge.....	Linton.....	71
Richard L. Anderson.....	Clinton.....	65

HOISTING ENGINEER EXAMINATION HELD AUGUST 25, 26 AND 27, 1904.

<i>Name.</i>	<i>Addresses.</i>	<i>No. of Certificate.</i>
Chas. W. Miller.....	Brazil.....	79
Wm. G. Spears.....	Brazil.....	85
James Williams.....	Washington.....	21
Picket P. Connott.....	Terre Haute.....	58
John B. Hosenohr.....	Terre Haute.....	89

MINE BOSS EXAMINATION HELD AUGUST 25, 26 AND 27, 1904.

<i>Name.</i>	<i>Addresses.</i>	<i>No. of Certificate.</i>
John Haag.....	Jasonville.....	25
D. W. Griffiths.....	Clinton.....	114
W. J. Winterbottom.....	Washington.....	111
David Owens.....	Linton.....	110
William R. Risher.....	Saline City.....	109
J. H. Needhammer.....	Jackson Hill.....	106
William White.....	Shelburn.....	107
John Mainey.....	Knightsville.....	103
John Blackwell.....	Vicksburg.....	41
George Geatches.....	Linton.....	95
H. C. Kasameyere.....	Newburg.....	93
John M. Lowry.....	Jasonville.....	92

<i>Name.</i>	<i>Address.</i>	<i>No. of Certificate.</i>
Neal Watts	Brazil	91
James Sidell	Atherton	89
H. E. Wilson	Burnett	88
Walter P. Lambert	Jasonville	87
James E. Johnson	Fontanet	77
Lawrence P. King	Burnett	76
C. A. Landine	Perth	104
J. V. Gustin	Farnsworth	74
Thomas S. Jenkins	Brazil .....	...
Burrell Wiley	Sullivan	65
Edward G. Lewis	Burnett	62

FIRE BOSS EXAMINATION HELD AUGUST 25, 26 AND 27, 1904.

<i>Name.</i>	<i>Addresses.</i>	<i>No. of Certificate</i>
Dave Murdock	Linton	98
Thomas Harrop	Dugger	33

HOISTING ENGINEER EXAMINATION HELD AUGUST 25, 26 AND 27, 1904.

<i>Name.</i>	<i>Address.</i>	<i>No. of Certificate.</i>
M. S. Smith	Burnett	94
Judge Williams	Clinton	101
Oscar Schalatter	Harmony	102
John Boucher	Brazil	80
Ray Lyday	Clinton	78
George M. Hubble	Merom	21
Ralph C. Payton	Hillsdale	50
N. H. Brown	Sullivan	24
Walter S. Neal	Jasonville	5
Will C. Witt	Bicknell	6
W. R. Maddex	Linton	8
Mark McConnell	Farmersburg	12
Joseph Bisoh	St. Marys	19
John Harlove	Farnsworth	2
O. M. Hicks	Midland	51
A. C. Stewart	Fort Branch	3
Grant Johnson	Shelburn	55
D. G. Sims	Linton	52
Clarence Sides	Fort Branch	56
B. J. Hixon	Terre Haute	57
Archie Kelly	W. Terre Haute	60
Geo. Arrowsmith	Fontanet	63
Hodson Neal	Delcarbo	69
Raymond L. Bevis	Terre Haute	72
Winford Crager	Dugger	49
Charles W. Miller	Brazil	—
Wm. G. Spears	Brazil	—

SERVICE CERTIFICATES.

Seventeen service certificates were granted within the year, as follows: Mine Boss, 11; Fire Boss, 1; Hoisting Engineer, 5. Following will be found the names and addresses of those to whom certificates were issued:

MINE BOSS.

<i>Name.</i>	<i>Addresses.</i>	<i>Date.</i>
Chas. A. Gilmon	Alum Cave	March 17
Samuel L. Price	Vincennes	June 1
Wm. E. White	Evansville	June 1
John Brownlee	Terre Haute	June 1
Wm. S. Osborn	Carbon	June 21
Robert Straughn	Rosedale	June 17
Omer Bolinger	Shelburn	July 7
Chas. Bennett	Corey	July 7
Herbert Haag	Cannelsburg	July 10
Ralph Sharpe	Cummins	Aug. 15
Henry L. Pirtle	Alum Cave	Aug. 6

FIRE BOSS.

<i>Name.</i>	<i>Address.</i>	<i>Date.</i>
William Wilson	Sullivan	April 21

HOISTING ENGINEER.

<i>Name.</i>	<i>Addresses.</i>	<i>Date.</i>
H. S. Shee	Terre Haute	Dec. 22
Jas. E. Stull	Washington	Feb. 29
Ephriam Colbert	Washington	Jan. 15
Jas. Trulove	Clinton	Jan. 15
Von O. Lambert	Ehrmandale	Aug. 12

TABLE,

Showing by Counties Names of Mines, Geological Number of Coal Seams, Thickness of Coal Seams by Feet and Inches, Depth of Coal in Feet, and the Nature of Roof and Floor.

BLOCK COAL MINES.

CLAY COUNTY.

NAME OF MINE.	Geological No. of Coal Seam.	Thickness of Coal Seam.	Depth to Coal Seam.	Nature of Roof.	Nature of Floor.
Brazil Block No. 1.....	IV	3' 8"	101	Gray shale	Sandy under-clay.
Diamond No. 5.....	IV	3' 6"	43	Gray shale	Sandy under-clay.
Brazil Block No. 7.....	IV	4' 6"	Slope	Gray shale	Sandy under-clay.
Brazil Block No. 8.....	III	3' 8"	89	Sand shale	Light under-clay.
Brazil Block No. 10.....	III	3' 6"	65	Sand shale	Light under-clay.
Continental.....	III	4' 6"	65	Sand shale	Light under-clay.
Reb Stock.....	III	3' 3"	86	Sand shale	Light under-clay.
Lawrence No. 6.....	III	4' 5"	41	Sand shale	Light under-clay.
Lawrence No. 7.....	IV	3' 7"	82	Blue shale	Sandy under-clay.
Cornwall.....	IV	4' 6"	86	Gray shale	Sandy under-clay.
Crawford No. 5.....	III	3' 8"	86	Sand shale	Light under-clay.
Crawford No. 6.....	III	2' 6"	116	Sand shale	Light under-clay.
Crawford No. 7.....	IV	3' 8"	84	Blue shale	Sandy under-clay.
Crawford No. 8.....	III	3' 6"	84	Sand shale	Light under-clay.
Crawford No. 8.....	III	3' 9"	50	Sand shale	Light under-clay.
Lower Vein Block.....	IV	3' 9"	48	Gray shale	Sandy under-clay.
Crawford No. 9.....	IV	4' 6"	86	Blue shale	Sandy under-clay.
Monarch.....	IV	3' 6"	81	Blue shale	Sandy under-clay.
Dan Davis.....	IV	3' 6"	57	Blue shale	Sandy under-clay.
Crawford No. 4.....	IV	4' 6"	57	Blue shale	Sandy under-clay.
Brazil Block No. 4.....	III	4' 6"	160	Sand shale	Light under-clay.
Superior No. 4.....	IV	3' 8"	90	Blue shale	Sandy under-clay.
Superior No. 4.....	IV	3' 6"	58	Blue shale	Sandy under-clay.
Superior No. 4.....	III	3' 6"	248	Gray shale	Light under-clay.
Eureka No. 5.....	IV	2' 6"	116	Gray shale	Light under-clay.
Indiana Block Coal Co.....	IV	3' 6"	58	Gray shale	Sandy under-clay.
Crawford No. 2.....	IV	3' 6"	68	Blue shale	Sandy under-clay.

BITUMINOUS MINES

CLAY COUNTY.

Cloverland No. 1.....	VI	7'	100	Brown shale ...	Dark under-clay.
Cloverland No. 2.....	VI	7'	90	Brown shale ...	Dark under-clay.
Fair View.....	VI	7'	.....	Brown shale ...	Dark under-clay.
Klondike.....	VI	6' 9"	25	Brown shale ...	Dark under-clay.
Gifford No. 1.....	III	4' 4"	110	Sand shale	Light under-clay.
Gifford No. 2.....	III	4' 6"	75	Sand shale	Light under-clay.
Fortner.....	V	3' 4"	100	Black shale	Bluish under-clay.
Glen No. 1.....	III	4' 6"	101	Sand shale	Light under-clay.
Glen No. 2.....	IV	4' 6"	.....	Blue shale	Sandy under-clay.
Glen No. 2.....	III	3' 3"	.....	Sand shale	Light under-clay.
Pearl.....	VI	7'	32	Brown shale	Dark under-clay.
Lewis.....	V	9'	77	Black shale	Bluish under-clay.
Vivian No. 4.....	III	5' 6"	107	Gray shale	Dark under-clay.
Vivian No. 5.....	IV	5' 6"	43	Gray shale	Sand grit.
Gold Knobb.....	III	6' 6"	.....	Dark shale	Dark under-clay.
Island Valley No. 4.....	IV	5' 6"	104	Massive sand- stone	Sand grit.

DAVIESS COUNTY.

NAME OF MINE.	Geological No. of Coal Seam.	Thickness of Coal Seam.	Depth to Coal Seam.	Nature of Roof.	Nature of Floor.
Hoosier.....	III	3' 7"	50	Sandstone.....	Light under-clay.
Montgomery No. 2.....	V	3' 8"	65	Sandstone.....	Bluish under-clay.
Montgomery No. 3.....	V	3' 8"	100	Sandstone.....	Bluish under-clay.
Union.....	V	3'	50	Sandstone.....	Bluish under-clay.
Mutual.....	III	4' 6"	100	Gray shale.....	Light under-clay.
Wheatland.....	VII	5'	100	Gray shale.....	White under-clay.
Mandabach.....	V	6'	56	Black shale.....	Bluish under-clay.

FOUNTAIN COUNTY.

Rush.....	.....	.....	.....	.....	.....
Silverwood.....	.....	.....	.....	.....	.....

GIBSON COUNTY.

Fort Branch.....	VI	5'	262	Brown shale....	Dark under clay.
Oswald.....	V	6' 10"	450	Gray shale.....	Bluish under-clay.
Massy.....	V	4' 6"	50	Black shale.....	Bluish under-clay.

GREENE COUNTY.

Black Creek.....	IV	4' 8"	.....	Gray shale.....	Sand grit.
Island No. 1.....	IV	5'	66	Gray shale.....	Sand grit.
Pennsylvania Co.....	III	7' 6"	217	Brown shale....	Dark under clay.
Island No. 2.....	IV	5'	95	Gray shale.....	Sand grit.
Island No. 3.....	IV	5'	72	Gray shale.....	Sand grit.
Island No. 5.....	IV	5'	55	Gray shale.....	Sand grit.
Gilmour.....	IV	5' 4"	152	Gray shale.....	Sandstone.
Hoosier No. 1.....	IV	3' 7"	133	Massive sand- stone.....	Sandstone.
Hoosier No. 2.....	V	7'	46	Black shale....	Bluish under-clay.
Island Valley No. 2.....	V	7' 6"	105	Black shale....	Bluish under-clay.
Island Valley No. 3.....	IV	5' 6"	47	Gray shale.....	Sand grit.
Island Valley No. 4.....	IV	5' 6"	104	Massive sand- stone.....	Sandstone.
South Linton.....	IV	5'	81	Gray shale.....	Sand grit.
Midland.....	III	7'	245	Brown shale....	Dark under-clay.
Vulcan.....	V	7'	.....	Black shale....	Dark under-clay.
Summit No. 2.....	IV	5' 6"	150	Gray shale.....	Sand grit.
Templeton.....	IV	5'	52	Gray shale.....	Sand grit.
Victoria.....	IV	5' 8"	122	Gray shale.....	Sand grit.
Glenburn.....	IV	4' 6"	102	Gray shale.....	Sand grit.
Antioch.....	IV	4' 6"	176	Gray shale.....	Sand grit.
Tower Hill.....	III	7'	132	Brown shale....	Dark under-clay.
Green Valley.....	IV	5' 2"	127	Massive sand- stone.....	Sandstone.
Lattie Creek.....	IV	5'	153	Gray shale.....	Sandstone.
Atlas No. 1.....	IV	5' 6"	132	Gray shale.....	Sand grit.
Atlas No. 2.....	IV	5'	128	Gray shale.....	Sand grit.
Fry.....	IV	3' 7"	87	Gray shale.....	Black bituminous shale
Letsinger.....	III	7' 6"	.....	Brown shale....	Dark under-clay.
North West.....	III	7' 6"	217	Brown shale....	Dark under-clay.
.....	IV	5'	75	Gray shale.....	Sand grit.
Twin.....	IV	4'	56	Black shale....	Fire clay.
.....	IV	4'	152	Gray shale.....	Sand grit.
North Linton.....	IV	4' 2"	68	Gray shale.....	Sand grit.

REPORT OF STATE GEOLOGIST.

BITUMINOUS MINES—Continued.

KNOX COUNTY.

NAME OF MINE.	Geological No. of Coal Seam.	Thickness of Coal Seam.	Depth to Coal Seam.	Nature of Roof.	Nature of Floor.
Knox.....	VI	4' 4"	103	Brown shale...	Dark under-clay.
Bicknel.....	VI	4' 4"	92	Brown shale...	Dark under-clay.
Prospect Hill.....	VII	3'	335	Lightgr'y shale	White under-clay.
Enterprise.....	VI	4' 3"	154	Brown shale...	Dark under-clay.
Pine Knot.....	VI	4' 6"	210	Brown shale...	Dark under-clay.

BLOCK MINES.

PARKE COUNTY.

Brazil Block No. 12.....	III	3' 6"	98	Sand shale.....	White under-clay.
Mary.....	III	4' 10"	106	Sand shale.....	White under-clay.
Crawford No. 10.....	III	5'	108	Sand shale.....	White under-clay.
Superior No. 1.....	IV	4'	135	Gray shale.....	Sandy under-clay.
Superior No. 2.....	III	3' 6"	40	Sand shale.....	White under-clay.
Superior No. 3.....	IV	3' 8"	64	Gray shale.....	Sandy under-clay.
Pan-American.....	III	4'	70	Sand shale.....	White under-clay.
Brazil Block No. 9.....	IV	4' 6"	120	Sand shale.....	White under-clay.
				Gray shale.....	Sandy under-clay.

BITUMINOUS MINES.

PARKE COUNTY.

Lyford No. 1.....	VI	6' 6"	.....	Brown shale...	Dark under-clay.
Park No. 11.....	VI	6' 6"	102	Brown shale...	Dark under-clay.
Harrison.....	IV	4'	.....	Gray shale...	Sandy under-clay.
Cox No. 3.....	VI	6'	94	Brown shale...	Dark under clay.
Lucia.....	VI	4'	134	Sand shale...	White under-clay.
Minshal No. 1.....	III	4' 6"	150	Sand shale...	White under-clay.
Minshal No. 2.....	III	5'	.....	Sand shale...	White under-clay.
Briar Hill.....	VI	5'	Drift	Brown shale...	Dark under-clay.
Mecca No. 3.....	III	5'	166	Gray shale...	White under-clay.
Mecca No. 4.....	III	5' 6"	.....	Gray shale...	White under-clay.

PERRY COUNTY

Lincoln.....	II	3' 4"	Slope	.....	.....
Troy.....	II	3'	50	Massive sand- stone.....	Sandstone.
Cannelton.....	II	.....	.....	.....	.....

PIKE COUNTY.

Aberdeen.....	V	4' 6"	43	Black shale...	Bluish under-clay.
Ayrshire No. 3.....	V	5'	22	Sandstone.....	Light under-clay.
Ayrshire No. 4.....	V	4' 8"	Slope	Sand shale...	Light under-clay.
Ayrshire No. 5.....	V	5'	Drift	Black shale...	Bluish under-clay.
Ayrshire No. 6.....	V	4' 10"	Drift	Black shale...	Bluish under-clay.
Blackburn.....	V	6' 6"	Slope	Black shale...	Bluish under-clay.
Littles.....	V	6' 6"	80	Black shale...	Bluish under-clay.
Rogers.....	V	7'	Slope	Black shale...	Bluish under-clay.
Hartwell.....	V	5'	Drift	Black shale...	Bluish under-clay.
Petersburg.....	V	5'	52	Black shale...	Bluish under-clay.
Carbon.....	V	4' 6"	Slope	Black shale...	Bluish under-clay.
Winslow No. 2.....	V	5'	Slope	Black shale...	Bluish under-clay.
Winslow No. 3.....	V	5'	Slope	Black shale...	Bluish under-clay.
Winslow No. 4.....	V	4' 10"	.....	Black shale...	Bluish under-clay.

SULLIVAN COUNTY.

NAME OF MINE.	Geological No. of Coal Seam.	Thickness of Coal Seam.	Depth to Coal Seam.	Nature of Roof.	Nature of Floor.
Phoenix No. 1.....	V	7'	37	Black shale....	Bluish under-clay.
Phoenix No. 2.....	V	7'	Slope	Black shale....	Bluish under-clay.
Star City.....	VI	5' 6"	120	Brown shale....	Dark under-clay.
Shelburn.....	V	6'	.....	Black shale....	Bluish under-clay.
Bunker Hill.....	VI	4' 6"	72	Brown shale....	Dark under-clay.
Dugger.....	VI	5'	105	Brown shale....	Dark under-clay.
Jackson Hill No. 2.....	VI	5' 8"	104	Brown shale....	Dark under-clay.
Jackson Hill No. 4.....	VI	5'	155	Brown shale....	Dark under-clay.
West Linton.....	VI	4' 8"	50	Brown shale....	Dark under-clay.
Hymera No. 4.....	III	6'	.....	Gray shale....	Sandy under-clay.
Hymera No. 2.....	V	7'	105	Black shale....	Bluish under-clay.
Caladonia.....	V	5' 3"	106	Brown shale....	Dark under-clay.
Freeman.....	VI	5'	100	Brown shale....	Dark under-clay.
White Ash.....	V	6'	53	Black shale....	Bluish under-clay.
Green Hill.....	VI	4' 6"	120	Brown shale....	Dark under-clay.
Sun Flower.....	VI	6'	.....	Brown shale....	Dark under-clay.
Glendora.....	VI	5'	110	Brown shale....	Dark under-clay.
Wilfred No. 1.....	VI	5' 6"	103	Brown shale....	Dark under-clay.
Island No. 4.....	IV	5' 6"	260	Gray shale....	Gray shale.
Mammoth.....	VI	6'	173	Brown shale....	Dark under-clay.
Little Giant.....	VI	5' 6"	.....	Brown shale....	Dark under-clay.
Cummins.....	VII	5'	Slope	Lightgrayshale	White under-clay.
Lablanch.....	VI	5' 6"	80	Brown shale....	Dark under-clay.
Citizens.....	VI	5'	165	Brown shale....	Dark under-clay.
Bruilettes No. 6.....	VII	5' 6"	80	Lightgrayshale	White under-clay.
Mildred.....	VI	5'	144	Brown shale....	Dark under-clay.
Virginia.....	VI	6'	200	Brown shale....	Dark under-clay.
Superior.....	VII	5' 6"	112	Lightgrayshale	White under-clay.
Shirley Hill.....	VI	5' 6"	110	Brown shale....	Dark under-clay.
St. Clair.....	VI	5' 6"	197	Brown shale....	Dark under-clay.
Jackson Hill No. 4.....	VI	5' 6"	155	Brown shale....	Dark under-clay.
Hymera No. 3.....	V	6'	.....	Black shale....	Bluish under-clay.
Kettle Creek.....	VI	5' 3"	152	Brown shale....	Dark under-clay.
Phoenix No. 4.....	VI	6' 6"	.....	Brown shale....	Bone coal.
Reliance.....	VI	5'	237	Brown shale....	Bone coal.
Union.....	VI	5' 6"	235	Brown shale....	Dark under-clay.
Clover Leaf.....	IV	5' 9"	306	Graysand shale	Sandy under-clay.
Hamelton.....	III	6' 6"	255	Dark gray shale	Dark under-clay.
Fairbanks.....	VI	5' 6"	248	Brown shale....	Dark under-clay.
Linton Semi-block.....	III	6' 6"	235	Dark gray shale	Dark under-clay.

VANDERBURGH COUNTY.

Sunnyside.....	V	4'	255	Black shale....	Bluish under-clay.
Unity.....	V	4'	225	Black shale....	Bluish under-clay.
First Avenue.....	V	4'	265	Black shale....	Bluish under-clay.
Diamond.....	V	4'	256	Black shale....	Bluish under-clay.
Union.....	V	4'	235	Black shale....	Bluish under-clay.
Ingle-side.....	V	4'	235	Black shale....	Bluish under-clay.

VERMILION COUNTY.

Buckeye.....	VII	4' 8"	149	Black bitum- inous shale....	Under-clay and shale.
Bruilettes Creek No. 3.....	VI	6'	265	Gray shale....	Dark under-clay.
Bruilettes Creek No. 5.....	VII	4' 10"	85	Black bit. shale	Dark under-clay.
Prince.....	VII	4' 10"	130	Black bit. shale	Dark under-clay.
Bureka.....	VII a	5'	110	Gray clod.....	Dark under-clay.
(See note).....	VI	.....	.....	.....	.....
Oak Hill.....	VII	4' 10"	40	Black bit. shale	Dark under-clay.
Willow Grove.....	VI	6'	176	Brown shale....	Dark under-clay.
Crown Hill No. 1.....	VII	5' 6"	164	Black bit. shale	Dark under-clay.
Crown Hill No. 2.....	VII	5'	151	Black bit. shale	Dark under-clay.
Rhodes.....	VII	5' 6"	100	Black bit. shale	Dark under-clay.
Maple Valley.....	VII	6' 8"	.....	Black bit. shale	Dark under-clay.

BITUMINOUS MINES—Continued.

VIGO COUNTY.

NAME OF MINE.	Geological No. of Coal Seam.	Thickness of Coal Seam.	Depth to Coal Seam.	Nature of Roof.	Nature of Floor.
Atherton.....	VI	6' 9"	165	Brown shale ...	Dark under-clay.
Brick Works.....	VII	4' 4"	85	Black shale	Dark under-clay.
Chicago No. 6.....	VI	7'	133	Brown shale	Dark under-clay.
Diamond.....	VI	6'	54	Brown shale	Dark under-clay.
Peerless.....	VI	7'	101	Brown shale	Dark under-clay.
Lawton.....	VI	6' 6"	110	Brown shale	Dark under-clay.
Ehrlich.....	VI	7'	99	Brown shale	Dark under-clay.
Grant No. 2.....	VI	6' 6"	120	Brown shale	Dark under-clay.
Glen Oak.....	VI	6' 6"	.....	Brown shale	Dark under-clay.
Hector.....	VI	7'	133	Brown shale	Dark under-clay.
Klondike No. 1.....	VI	6' 6"	Slope	Brown shale	Dark under-clay.
Miami No. 1.....	VI	7'	32	Brown shale	Dark under-clay.
Red Bird.....	VI	6'	90	Brown shale	Dark under-clay.
Rosebud No. 2.....	VI	6' 6"	110	Brown shale	Dark under-clay.
Royal No. 1.....	VI	6'	103	Brown shale	Dark under-clay.
Larimer.....	VII	4' 8"	110	Black shale	Dark under-clay.
Broadhurst.....	VII	4' 4"	80	Black shale	Dark under-clay.
Miami No. 2.....	VI	6'	50	Brown shale	Dark under-clay.
Deep Vein.....	VI	6'	170	Brown shale	Dark under-clay.
Greenfield No 1.....	VI	.....	.....	Brown shale	Dark under-clay.
Lost Creek.....	VI	6'	120	Sandstone	Dark under-clay.
Sugar Creek.....	VI	.....	105	Black shale	Bluish under-clay.
Ray No. 2.....	VI	7' 4"	95	Brown shale	Dark under-clay.
Miami No. 3.....	VI	7'	85	Brown shale	Dark under-clay.
Riverside.....	VII	.....	110	Black shale	Dark under-clay.
Forest Park.....	VI	6' 5"	150	Blue sand shale	Bone coal.
Domestic Block (See note)	IV	4'	108	Massive sand rock	Gray shale.

WARRICK COUNTY.

Star No. 1.....	V	4' 4"	100	Sand rock	Bluish under-clay.
Star No. 2.....	V	4' 4"	110	Sand rock	Bluish under-clay.
Air Line.....	V	5' 6"	100	Black shale	Bluish under-clay.
Chandler.....	V	.....	.....	Black shale	Bluish under-clay.
Big Four.....	V	7'	Slope	Black shale	Bluish under-clay.
De Forrest.....	V	7'	65	Black shale	Bluish under-clay.
Electric.....	V	7'	30	Black shale	Bluish under-clay.
Big Vein No. 3.....	V	7'	37	Black shale	Bluish under-clay.
Goslee.....	V	4'	87	Black shale	Bluish under-clay.

NOTE 1—The two seams of coal No. VIa and VI are mined together in the Eureka Mine, being separated by a small dirt band of a few inches in thickness.

NOTE 2—The seam mined at the Domestic Block Mine is block coal, this being the only block mine in Vigo County.

NOTE 3—The floor underlying Coal No. IV changes in nature very much in different parts of the field. In the vicinity of Brazil it is a sandy fire clay and is very hard when first mined but weathers in a few weeks to a fine grained plastic mass and is used in the manufacture of hollow brick, sewer pipe and other clay products. In the Linton field it is a hard sand grit resembling very much a mass of sand cemented together with no seams and a total absence of clay. In the Jasonville field it is a hard white massive sandstone, while at the Island No. 4 Mine, near Dugger, in Sullivan County, the formation immediately under the coal for about three feet is a dark gray shale.

FATALITIES AND INJURIES.

An aggregate of two hundred and forty-seven (247) to mine employes was reported to this office during the year 1904, classified as follows: Fatal, thirty-four (34); serious, one hundred and thirty-two (132), and minors, eighty-one (81). The causes of the accidents and the occupation of those injured are shown in the two following tables:

TABLE,

*Exhibiting the Number of Casualties Arising in Indiana Mines
Year 1904, and the Different Causes Thereof.*

CAUSE OF ACCIDENT.	Fatal.	Serious.
Falling slate.....	13	38
Falling coal.....		15
Smoke explosion.....	1	2
Powder explosions.....	3	5
Delayed shots.....	5	3
Premature shots.....		5
Blown out shots.....		1
Misplaced shots.....		1
Mine cages.....		9
Kicked by mule.....		2
Mine cars.....	6	39
Falling down shaft.....	4	1
Mining machines.....		3
Railroad cars.....		1
Electric shock.....	1	1
Miscellaneous.....		
Dust explosion.....		3
Fell off scaffold.....		1
Coal falling down shaft.....		2
Total.....	34	132

TABLE,

*Exhibiting the Number of Fatal and Serious Accidents Arising During the Year 1904,
the Different Occupations of Persons Injured and Cause of Accident.*

	Miners.	Machine Runners.	Loaders.	Drivers.	Jerries.	Track Men.	Timbermen.	Shooters.	Pumpers.	Cagers.	Mine Bosses.	Carpenters.	Flat Trimmers.	Outside Labor.	Sinkers.	Total.
Falling slate.....	31	2	2	7	3	1	3	...	1	...	1	...	...	...	...	51
Falling coal.....	15	...	...	...	...	...	...	...	...	...	...	...	...	...	...	15
Smoke explosion.....	2	...	...	...	...	...	...	1	...	...	...	...	...	...	...	3
Powder explosions.....	3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	3
Delayed shots.....	3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	3
Premature shots.....	5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	5
Blown-out shots.....	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1
Misplaced shots.....	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1
Dust explosions.....	3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	3
Mine cages.....	3	...	...	...	...	...	...	...	...	1	...	...	...	...	...	3
Kicked by mule.....	...	...	...	2	...	...	...	...	...	...	...	...	...	...	...	2
Mine cars.....	7	...	...	33	...	...	...	...	...	...	...	...	...	...	...	45
Mining machines.....	...	3	...	...	...	...	...	...	...	...	...	...	...	...	...	3
Falling down shaft.....	2	...	...	...	...	...	...	...	...	...	...	1	...	2	...	5
Electric shock.....	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2
Railroad cars.....	...	...	...	...	...	...	...	...	...	...	...	...	1	...	1	2
Coal falling down shaft.....	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2
Falling off scaffold.....	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1
Total.....	96	5	2	47	3	1	3	1	1	1	1	1	1	2	1	166

FATAL ACCIDENTS.

The following is a detailed statement of facts and circumstances attending each of the fatal accidents that have taken place in the mines of this State during the year 1904, as established by investigation made either by myself or one of my assistants acting in conjunction with the coroner of the county in which the accidents have occurred; also, some comments on same:

CLAY COUNTY.

The first mine accident resulting in death occurred on January 13th, in the Collins Coal Company's No. 1 Mine, at about 8:30 o'clock on the morning of the above date. Thomas Welch, a miner, 68 years of age, employed at this mine, was working at the face of his room, when, apparently without warning, a large iron-stone boulder (commonly called by miners a nigger head), measuring six feet in length, five feet wide and twelve inches thick, suddenly gave way, falling on him, crushing and injuring him so

that he died a few minutes later. On examination it was found that the boulder had been almost completely imbedded in the roof, with only a small portion of the lower surface visible, showing on a line with the roof, and, being of different formation, also separated it from the strata surrounding it by a glaze or thin coating of coal. It was practically without support, loose and ready to fall when the coal had been mined from under it. This dangerous condition, however, was not noticeable, and would have been very hard to determine either by examining or by sounding the roof; therefore, decedent could not have been aware of the danger he was working in until the rock fell, resulting in his death.

On February 16th Charles Patrick, a miner, 17 years of age, was killed by falling draw slate in the Collins Coal Company's No. 2 Mine. Little was learned at the investigation of this accident other than that deceased was last seen alive at about 11:30 o'clock a. m. of the above date, at which time he informed the driver, who was then pulling a car of coal from his room, that he would load no more coal that day, and as his working place was located some distance from those of his fellow-workmen, no one had occasion to visit him during the day. At about 7:30 o'clock p. m. a searching party found him at the face of his room lying under a piece of draw slate which measured ten feet long, five feet wide and six inches thick. Life had then been extinct for several hours.

On April 13th Allen Payne, a miner, 23 years of age, was instantly killed by a delayed bottom shot in the Lower Vein Block Coal Company's No. 1 Mine. This accident was investigated by Assistant Inspector Thomas, and from evidence given at the investigation it was learned that at firing time (3:25) on the evening of the above date Walter King, a miner, whose working place was near that of the deceased, had two shots ready to fire, one of which was tamped on fuse, the other to be fired by a squib. A day man named Wilson also had a bottom shot, which was charged with one and one-half pounds of dynamite, ready to fire in the same room. Arrangements were made that Payne should assist King in firing his shots, they to light one shot each at the same time that Wilson would light the bottom shot. In the hurry and excitement incident to such work Wilson lighted the bottom shot before the others were quite ready, and warned them of the fact.

King succeeded in lighting his squib, but deceased failed to light the fuse in the shot he was trying to fire. They then ran to a place of safety, and, after waiting about one minute or so, two shots were heard to explode, which they thought were in King's room. Several other shots were being fired at the same time in this part of the mine, and after results proved that it was one of these that they heard instead of the bottom shot. After hearing the two shots explode they rushed back into the room to fire the one which Payne failed to light, and when decedent had gotten directly over the bottom shot it exploded, killing him instantly and seriously injuring King. Deceased leaves a wife and two children. A conformance to the statute requiring shots to be fired in rotation might have prevented this accident.

GREENE COUNTY.

On March 31st Samuel Thorp, assistant mine boss, age 40 years, was crushed by falling slate in the Lattas Creek No. 1 Mine, sustaining internal injuries that resulted in heart failure, of which he died on the night of April 17th.

From evidence given at the investigation of the accident it was learned that on the morning of the 31st deceased had been instructed to take assistance with him and shoot down some slate which had become loose and dangerous on one of the main entries. A hole had been drilled in the slate on the day previous, and his instructions were to charge this hole and fire a shot in the slate. Instead of following instructions, he proceeded to knock out the timbers from under the slate with a sledge hammer, and while so engaged, at about 8 o'clock a. m., a large piece of slate, eight feet wide, thirty feet in length and eight inches thick, suddenly gave way and fell, the outer edge striking him and inflicting injuries as above stated. It was not thought at the time that he was seriously injured, and there is some doubt as to whether his death was due to injuries received from the slatefall or not. He leaves dependent one child.

On June 16th W. L. Haskins, miner, age 32 years, was fatally injured by a blast in the Victoria Mine. At firing time, 3:30 o'clock p. m., of the above date, deceased and another miner named Dority, who was working in the room adjoining that of the deceased, had two shots each charged, ready to fire, all of

MINE ACCIDENTS

Haskins while he made what they both thought was the successful attempts to ignite the fuse in the shot he was firing. (Later results, however, proved that the fuse ignited in one of the three attempts.) After waiting thought there was danger from the shots he had previously Dority called to Haskins, and they ran to a place of safety they waited an interim of perhaps three minutes, during time they heard three shots explode. Haskins then, thinking he had failed to light his shot, rushed back into his place the purpose of doing so, and when within ten or twelve feet the shot exploded, pieces of coal from it striking and injuring so badly that he died on the following morning. He left dependents a wife and three children. Two very dangerous practices are exhibited in this accident, viz., the use of fuse firing and that of trying to fire more than one shot at a time. Had the ordinary miners' squibs been used and but one fired at a time in rotation, as required by law, the accident undoubtedly not have happened.

On July 7th Thomas McClelland, miner, age 50 years, fatally injured by falling down the Glenburn hoisting shaft at the time he met his death deceased was employed as a dumper at the top of the mine, in which capacity he was temporarily employed, during the time certain repairs were made in the bottom. His place of work was at what is known as the dirt landing, located about twelve feet above the first landing. He and one other person were employed at this point, their duties being to pull the loaded cars off the track they were hoisted, push them to a point some 400 feet from the shaft, dump and return the empty cars to the shaft. About 9 o'clock on the morning of the accident they had just taken a loaded car off the cage and during the interval between the time to return the empty the mine superintendent, wishing to go into the mine, caused the cage to be lowered. The man returning with the empty car, not knowing that the cage had been moved, pushed it over into the shaft. McClelland, while clinging to it, was also pulled into the shaft, falling a distance of about seventy feet, striking the top of the shaft receiving injuries from which he died during the night. He leaves as dependents a wife and eight children. The

which were tamped on fuse. Arrangements were made that Dority should light his two shots first, then pass through the breakthrough between the two rooms and assist Haskins to fire, they to light one shot each at the same time, thus lighting the four shots in rotation before any one of them would have time to explode. This they proceeded to do, and Dority had lighted both of his shots and one of those in Haskins' room, and was watching tendent, as did others, gave evidence at the investigation that he had called twice to the dumpers notifying them that he intended using the cage, yet the dumper who was working with McClelland testified that they had heard no such order. Be that as it may, the superintendent, knowing the danger of moving the cage under existing conditions, should be censured in not waiting until fully assured that both men had heard his order before causing the cage to be moved.

On December 23d a second fatal accident occurred in this mine, when Raymond Little, driver, age 17 years, and single, was crushed to death beneath a loaded mine car in the Glenburn Mine.

No one witnessed this accident, and little could be learned at the investigation other than when last seen alive decedent was coming out of a cross-entury with a loaded car, riding, by standing with one foot on the drawbar in the front end of the car and the other one on the tail chain. From the fact that the mule was loose from the car and was continuing on its way out of the entry when the accident was reported, it is presumed that the hook in the tail chain, in some way, became detached from the car, thus causing him to fall to the roadway directly in front of it. When found he was lying beneath the car, about the center, life extinct.

On October 25th Starlin Center, miner, age 32 years, single, was almost instantly crushed to death by falling slate in the Island No. 2 Mine. Deceased and several other persons were at work in the morning of the above date cleaning up and constructing a cut-off roadway through an old abandoned room to recover a pair of cross-entries which had caved in. At about 11:30 o'clock a. m. he was loading dirt from along the side of the room pillar, working under a ledge of slate which extended out over the roadway, when suddenly this slate ledge, measuring sixteen feet in length, three feet wide and eighteen inches thick, gave

way, falling on him, crushing him so that death resulted before the slate could be removed, an interim of perhaps five minutes.

On November 1st James Layman, driver, age 17 years, and single, was run over and crushed to death by a loaded mine car in the Black Creek Mine. Deceased was driving a parting team, hauling coal from a double parting on the main entry to the shaft bottom. At about 2:20 o'clock p. m. he was coming out with a trip of three loaded cars, riding on the front end of the first car, when, in some way, he slipped and fell under the car, which passed almost entirely over him, crushing and killing him instantly.

On December 9th a second fatal accident occurred in this mine. Larry Bays, miner, age 23 years, and single, was fatally injured by falling draw slate. There was no one present at the time the accident occurred, and when found by the driver, who had gone into his room to pull a car, at about 1:20 o'clock p. m., he was lying under a large piece of slate, unconscious, in which state he remained until death relieved him, at about 12 o'clock midnight of the same date.

KNOX COUNTY.

On August 16th George Ballow, age 34 years, and Tollard M. Goldman, age 45 years, sinkers, met their death by falling down an escape shaft which they were sinking for the Enterprise Hill Coal Company. An investigation of this accident was made by Assistant Inspector Thomas, at which time it was learned that the company, in providing a hoisting apparatus to be used in sinking this escape shaft, had converted a traction into a hoisting engine by covering one of the traction wheels with short wooden slats and using it as a winding drum. Ballow and Goldman were working on the night shift, and at about 11 o'clock p. m. of the above date had prepared to descend the shaft and begin their shift. After calling to the engineer, asking if all was right, and receiving an affirmative reply, they stepped into the sinking bucket and signaled him to lower away. The engineer started his engine and had unwound about fifteen feet of rope, when it suddenly slipped from the surface of the drum, thus allowing the bucket, with its human load, to fall about four feet, when the rope was caught by the main shaft of the engine, the sudden jerk

causing the men to lose their hold on the rope, falling to the bottom of the shaft, a distance of about 125 feet, killing them both instantly. Goldman leaves as dependents a wife and six children.

PARKE COUNTY.

On January 12th Bert Challis, driver, age 23 years, single, was crushed to death by a mine car in the Parke No. 11 Mine. There was no one present immediately at the time of the accident, and little was learned on investigation other than that when decedent was last seen alive he was riding on the front end of a loaded mine car, coming down a very heavy grade without spraggs. It is presumed that the car was running at a high rate of speed, and that he slipped and fell under it. When found he was lying under the car between the axles, life extinct.

PIKE COUNTY.

On January 13th Joseph Keys, miner, age 50 years, and Willis Hall, also a miner, age 30 years, were fatally burned by an explosion of blasting powder in the Carbon Mine. An investigation of this accident developed the fact that it was brought about by carelessness on the part of one of the decedents seldom exhibited by even those who are the most ignorant in the use and handling of explosives. The point at which the accident occurred was some forty feet from the face of Keys' working place, the location of his powder box, containing two full kegs of powder and one keg which had been partly used. A large hole had been made in the top of this keg, and it had been left standing open. The box also contained a roll of fuse which was thought to be damp. In order to determine this fact Keys took up the fuse and applied his lamp to the powder in the end of it, which ignited and commenced to burn, and while standing almost directly over the box, he cut off a short piece of the fuse, the burning end falling into the open powder keg, exploding the powder and burning him so badly that he died one week later. It was not thought at the time that Hall was fatally injured, yet death resulted two weeks from the date of the accident. Keys leaves as dependents a wife and one child and Hall a wife and three children.

On October 3d two more lives were sacrificed to the use of fuse

in shot firing. David Key, miner, age 49 years, and Evert Botkins, 37 years of age, also a miner, were killed by a blast in the Ayrshire No. 3 Mine. With the exception that two lives were lost, this accident is an exact counterpart of that occurring in the Victoria Mine in Greene County; i. e., Key had two shots ready to fire at firing time (3:30 o'clock p. m.), both of which were tamped on fuse, and Botkins was assisting him to fire them, they to light one shot each at the same time. Botkins succeeded in lighting his shot, and, thinking that Key had done the same, ran out on the entry to a place of safety with him, where they waited until they heard a shot explode. Key then said that he thought he had failed to get his shot lighted, Botkins replying that they had better get back and light it before the smoke got too strong. They then rushed back into the room for the purpose of doing so, and when within about fifteen feet of the shot it exploded, killing Key instantly and injuring Botkins so badly that he died six hours later. Both of the unfortunates leave as dependents a wife and three children each.

On October 26th Louis Mallory, miner, age 30 years, and single, was fatally injured by falling slate in the Ayrshire No. 4 Mine. At the time of the accident he was loading a car of coal from the end of a pillar which he was drawing, when a piece of draw slate suddenly gave way, striking him on the head, inflicting what was thought at that time to be merely a scalp wound. A few days later he took to his bed and was bleeding at the ears. A doctor was called and upon examination it was discovered that he had suffered a basilar fracture of the skull, and that an operation would be necessary to remove the blood clot on his brain. This was done, but Mallory did not recover, and died November 4th.

SULLIVAN COUNTY.

March 16th Elmer DeLapp, car greaser, age 15 years, was killed by falling slate in the Wilfred No. 1 Mine. Deceased was not working on the day of the accident, but he had gone down the manway into the mine in the afternoon visiting. Among other places he visited was that of a miner named Treadway, with whom he remained until firing time. Treadway had two shots ready to fire, which deceased insisted on lighting. He finally did

light one, against Treadway's wishes, and was returning to light the remaining one, when a large piece of draw slate, fifteen feet wide, seventeen feet long and from two to four inches thick, fell on him, killing him instantly.

March 16th Fred Cliver, miner, age 19 years, single, was fatally injured by an electric shock in the Sunflower Mine. From evidence given at the investigation of this accident it was learned that at about 9 o'clock on the morning of the accident the wick or cotton in decedent's lamp being nearly exhausted, he had gone into a neighbor's room to get a new one. Failing to get one there, he started out to try elsewhere. In leaving the room his lamp was extinguished, but he continued his way in the dark, and, miscalculating the distance he had traveled, came into contact with a live electric wire located across the entry from the mouth of the room. It is presumed that, being in the dark, he stumbled and fell, his face striking the wire. The contact only lasted from fifteen to thirty seconds, when assistance reached him, yet death resulted from the shock ten minutes later. Two hundred and fifty volts (the maximum electric load carried in this mine) is not considered dangerous to human life, unless the contact continues for a considerable length of time, yet two deaths have occurred in the mines of the State within the past eighteen months where the voltage carried was less than the above number, and in each instance the contact lasted but a few seconds. There should be a law enacted prohibiting the use of naked wires on traveling or haulage roads.

On June 3d Alfred McClelland, driver, age 20 years, was killed by falling slate in the Freeman Mine. At the time of the accident deceased was hauling water. At about 2:45 o'clock p. m. he was going into the mine with an empty water box, riding on the tail chain between the mule and the box, and when passing through a double parting on the main entry a piece of slate, three feet wide, seven feet long and four inches thick, fell on him, crushing his head against an iron rail, death resulting fifteen minutes later.

June 4th Perry Kirkham, miner, age 24 years, was fatally injured by falling slate in the Bruillette's Creek No. 6 Mine. He and his buddie were at work at the face of their room on the morning of the above date, loading a car of coal. At the time of the

accident decedent was shoveling coal from under a horse-back or roll, when suddenly, without warning, a large portion of it gave way, falling on him, crushing and injuring him so that he died within a few hours. He leaves as dependents a wife and one child. Considerable negligence on the part of both decedent and his buddie was exhibited in this accident, as they knew the nature of the roof, and that it was dangerous, having sounded and examined it a short time previous to the accident; yet they continued working under it without having first secured it with props or timber.

On May 26th John Griffin, timberman, age 36 years, single, was fatally injured by falling slate in the Jackson Hill No. 2 Mine. Shortly after 7 o'clock on the morning of the above date deceased was at work trying to take down a loose slate shot which had been fired on one of the cross-entries the previous evening. At the time of the accident he was shearing the slate through on one side of the entry for the purpose of loosening it more, so that it could be taken down easily, when suddenly, without warning, a large piece of slate, measuring eight feet wide, thirteen feet long and six inches thick, gave way, falling on him, crushing and injuring him so that he died two hours later.

On July 21st Edward White, driver, age 17 years, single, was instantly killed by being run over with a loaded mine car in the Caledonia Mine. There was no witness to this accident, and little could be learned at the investigation other than that when last seen alive decedent was riding on the front end of a trip of three loaded cars, on his way from a double parting to the shaft bottom. A few minutes later he was found under the front car of the trip, life extinct. The supposition is that he slipped and fell under the car, as there was evidence on the roadway of his having been dragged about seventy-five feet before the trip was stopped.

On September 14th Samuel E. Shepherd, age 26 years, was killed by falling slate in the Union Mine. Deceased and eight other persons were at work on the night shift, shooting up bottom and timbering near the bottom of the shaft, preparatory to laying the double partings. At about 11:15 p. m. they had fired a shot which knocked a couple of props out from under some very loose slate, and were at work clearing away the débris, so that the props could be reset, when a large piece of slate, measuring four feet

wide, six feet long and twelve inches thick, suddenly gave way and fell, killing Shepherd instantly and seriously injuring two other persons. Deceased leaves a wife and one child.

On October 18th a second fatal accident occurred in the Bruillette's Creek No. 6 Mine, when Mathew Gibson, miner, age 21 years, single, met his death from falling slate. This accident was very similar to that of Kirkham. At about 8:30 o'clock a. m. decedent had gone to visit a fellow-miner named Clark, and while sitting near the face of the latter's room, talking, a large piece of roof of slip formation, which measured eight feet long, two and one-half feet wide and eighteen inches thick, suddenly gave way, falling on him and killing him instantly. Clark testified that he had examined and sounded the rock a short time prior to the accident, and could not detect that it was loose. Roof of this character is very treacherous, and cannot be watched too closely.

VERMILLION COUNTY.

On January 9th John Thompson, carpenter, age 51 years, single, met his death by falling down the Crown Hill No. 2 hoisting shaft. At the time of the accident (3:30 p. m.) Thompson was at work putting in some guides in the tippie, and was standing on a platform located about thirty-eight feet above the ground or surface landing, when a violent smoke explosion occurred in the mine. So great was the force of the explosion that it extended up into the tippie, causing decedent to lose his footing and fall to the bottom of the shaft, a distance of 193 feet, killing him instantly. From evidence obtained at the investigation of this accident it was learned that at quitting time of the above date there were thirty-five or forty shots ready to fire, containing in all at least two hundred and fifty, possibly more, pounds of powder. The shot firers commenced firing these shots at 3 o'clock p. m., and in about thirty minutes had completed their work. The last shot fired, however, seamed, making an unusually large amount of flame, and the smoke from so great a number of shots previously fired in so short a time being very dense and hot, ignited from this flame, causing an explosion of such force as to almost wreck the interior of the mine, also tearing out a part of the guides and midwall in the hoisting shaft. The shot firers, although nearly overcome with powder smoke and after-damp, escaped without serious injury.

On November 1st Matt Pugh, shot firer, age 34 years, was fatally burned from the flame of a blown-out shot in the Mine. Pugh and one other person were employed to fire in this mine after the miners and other workmen had completed their day's work and quit the mine. It was a custom of the shooters would take opposite sides of the shaft, began on the return of the air, and continue lighting shots until they had made a complete circuit of that part of the mine, or until the shots had been fired. At about 5 o'clock on the evening of the accident Pugh had fired a number of shots on one of the entries, when he came to a room where a shot had been placed which measured seven feet nine inches, right angles from the hole. It was also drilled three feet and five inches past the firing or loose end, and was charged with four quarts of powder. This shot, when exploded, caused a windy or blown-out shot, the flame of which traveled a distance of one hundred and sixty feet down the opposite cross-entry, where deceased had gone for safety, burning him externally and internally, inflicting injuries of which he died three days later in the St. Anthony Hospital at Terre Haute. He leaves as dependents a wife and four children. As shown by the above, this accident was due to a mischarged and misplaced shot and a gross violation of the statute relating to the use of powder and shot firing in mines by two persons, viz., Ante Lathi, the person who prepared the shot, and deceased himself, who had strict orders from the mine manager not to fire any shots that did not conform to statute. Prosecution was commenced against Lathi, but he had left the city immediately after the accident and we were unable to secure service on him.

December 30th Robert McCain, driver, aged 24 years, was killed, and was crushed to death by a trip of loaded mine cars in the Low Grove Mine. Deceased was employed at the mine as a rider, his duties being to ride the trip of empty cars in and out of the mine, and to load one out of the mine. When riding the loaded trip he usually rode on the front end of the first car in the trip, seated on what is termed a shoe, which consisted of a piece of strap one-fourth inch thick and four inches wide, turned at right angles so as to form two arms eight and twenty inches long, respectively. On the end of the long arm a loop or hook was turned so that it could be hooked over the end of the car. At about 10:40

a. m. he was coming out to the shaft with a trip of some eight or ten cars, and when within about one hundred feet of the shaft he in some way fell under the cars and was dragged through under the second one, breaking almost every bone in his body, killing him instantly. There was no one saw him fall, but it is presumed that he caught his foot against an iron roller placed in the center of the track for the purpose of carrying the rope, and was jerked off his seat to the roadway in front of the car.

VIGO COUNTY.

On March 4th, at about noon, Robert Cole, top laborer, age 25 years, single, was crushed to death by a railroad car in the yards of the Diamond Mine. At the time of the accident deceased was bringing an empty car down to the tippie, and when nearing the point where he wished to stop it he applied the brake. At that moment the chain connecting the brake rod and beam gave way, thus causing him to lose his footing and fall to the track directly in front of the car, where he was caught by the brake beam and crushed to death instantly.

On March 15th Osear King, miner, age 20 years, was fatally burned as a result of an explosion of blasting powder in the Grant No. 2 Mine. From evidence obtained at the investigation of this accident it was learned that at about 10 o'clock a. m. of the above date deceased had gone to his powder box for some needed article, and that he had in the box a powder keg containing about eight pounds of powder. The box was also a receptacle for his squib box, mine checks, paper and other articles that make up a miner's equipment. A large hole had been made with a pick in the top of the powder keg, for the purpose of pouring the powder out of it. This hole had been left uncovered, and when deceased raised the lid of the powder box a spark from his lamp fell into the keg, exploding the powder and burning him so badly that he died eight days later. He leaves as dependent a wife.

On September 17th a second fatal accident occurred in this mine, when Charles Powell, miner, age 21 years, was fatally injured by a delayed shot. At firing time (3:30 p. m.), this date, decedent had three shots charged ready to fire, all of which were tamped on fuse. When it came his turn to fire he lighted two of the shots and retreated to a place of safety on the entry, where

he waited until he heard what he thought was two shots. After results, however, proved that but one shot had been fired and that it made two reports, the concussion from the being almost equal to the first one. When he heard the reports decedent rushed back and lighted his remaining candles, was leaving the room, but when about twenty-two feet from the face of the room the unexploded shot that he had previously exploded, pieces of flying coal from it striking and injuring him that he died four hours later, one more victim as a result of the practices which we have from time to time severely condemned, viz., the use of fuse in shot firing and of trying to fire several shots at one time. Deceased leaves a dependent wife and three children.

On October 18th Peter Felor, miner, age 18 years, was fatally injured by being crushed between a loaded car and the entry rib in the Diamond Mine. From evidence gathered at the investigation of this accident it was learned that deceased was very anxious to secure a position as mule driver in the mine and in order that he might learn the work he spent a great deal of his time, when not otherwise engaged, in assisting the mule driver who hauled coal from him. At about 1:30 o'clock p. m. of the above date he had assisted in gathering a trip of loaded cars, after having coupled them together he started the trip and attempted to step up on the drawbar, where the driver was riding, but missed his footing. In order to save himself from being run down by the cars, which were then in motion, he ran to the one side of the roadway, intending to let them pass and then return to space, however, between the roadway and the rib was not sufficient to permit the cars to pass him, there being only about three feet of room. This fact, owing to his excitement, was not appreciated by deceased, and he was caught by the car and dragged under the entry rib for several feet before the trip could be stopped. He was crushed through the abdomen and injured other parts of his body. He died about midnight of the same date.

On November 29th John Dreganous, miner, age 42 years, was fatally crushed by falling slate in the Klondyke Mine. At about 10:30 o'clock a. m. he was engaged in mining off some slate in the upper bench of his room, working under a piece of draw slate five inches thick, when a piece of slate, eleven inches thick and five feet wide, suddenly gave way, falling and crushing him.

on the edge of the lower bench of coal, crushing him through the chest and inflicting injuries of which he died a short time after being brought out of the mine. There was no one present at the time of the accident. An examination of his working place, however, proved that he knew that the slate was loose, as there was evidence of his having tried to pull it down; also, that he resumed work under it without first having secured it with props, notwithstanding the fact that there were a number of props of different lengths on hand.

A summary of the names of persons killed, occupation, date and cause of each death, the name of mine and county in which the fatalities occurred, and the number of persons dependent on those killed is given in the following table:

SUMMARY OF FATAL CASUALTIES,
CLAY COUNTY.

Date.	Name.	Age.	Dependents.	Address.	Occupation.	Cause.	Mine.	Company.
Jan. 13	Thomas Welch	68	0	Brazil	Miner	Falling slate	Gifford No. 1	Collins Coal Co.
Feb. 16	Charles Patrick	17	0	Brazil	Miner	Falling slate	Gifford No. 2	Collins Coal Co.
April 13	Allen Payne	23	5	Saline City	Miner	Delayed shot	Lower Vein Blk	Lower Vein Blk. Coal Co.

GREENE COUNTY.

April 31	Samuel Thorp	40	1	Linton	Asst. mine boss	Falling slate	Lattas Creek No. 1	Lattas Creek Coal Co.
June 16	W. L. Haskins	42	4	Linton	Miner	Delayed shot	Victoria	Victoria Coal Co.
July 7	Thomas McClelland	50	9	Linton	Miner	Fell down shaft	Glenburn	L. T. Dickerson Coal Co.
Oct. 25	Starlin Center	32	0	Linton	Day man	Falling slate	Island No. 2	Island Coal Co.
Nov. 1	James Layman	17	0	Linton	Driver	Fell under mine car	Black Creek	Black Creek Coal Co.
Dec. 9	Larry Bays	23	0	Linton	Miner	Falling slate	Black Creek	Black Creek Coal Co.
Dec. 23	Raymond Little	17	0	Linton	Driver	Fell under mine car	Glenburn	L. T. Dickerson Coal Co.

KNOX COUNTY.

Aug. 8	George Ballow	34	0	Bicknell	Sinker	Fell down sinking shaft	Enterprise	Enterprise Coal Co.
Aug. 8	Follard Goldman	45	6	Bicknell	Sinker	Same accident	Enterprise	Enterprise Coal Co.

PARKE COUNTY

Jan. 12	Bert Challis	23	0	Rosedale	Driver	Mine car	Parke No. 11	Parke County Coal Co.
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SUMMARY OF FATAL CASUALTIES—Continued.

PIKE COUNTY.

Date.	Name.	Age.	Dependents.	Address.	Occupation.	Cause.	Mine.	Company.
Jan. 13.....	Joseph Keys.....	55	2	Carbon.....	Miner.....	Powder explosion.....	Carbon.....	Aberdeen Coal Co.
Jan. 13.....	Willis Hall.....	30	4	Carbon.....	Miner.....	Same accident.....	Carbon.....	Aberdeen Coal Co.
Oct. 3.....	David Rogers.....	49	4	Ayrshire.....	Miner.....	Delayed shot.....	Ayrshire No. 3.....	Ayrshire Coal Co.
Oct. 3.....	Evert Rogers.....	49	4	Ayrshire.....	Miner.....	Same accident.....	Ayrshire No. 3.....	Ayrshire Coal Co.
Oct. 26.....	Louis Mallory.....	30	0	Ayrshire.....	Miner.....	Falling slate.....	Ayrshire No. 4.....	Ayrshire Coal Co.

SULLIVAN COUNTY.

March.....	Elmar Delap.....	15	15	Wilfred.....	Miner.....	Falling slate.....	Wilfred.....	Wilfred Coal Co.
March 16.....	Fred Oliver.....	19	19	Dugger.....	Miner.....	Electric shock.....	Sundowner.....	Sundowner Coal Co.
May 26.....	John Griffin.....	36	36	Jackson Hill.....	Miner.....	Falling slate.....	Jackson Hill No. 2.....	Jackson Hill Coal Co.
June 3.....	Alfred McTielland.....	20	20	Dugger.....	Driver.....	Falling slate.....	Freeman.....	Sullivan Coal Co.
July 21.....	Edward White.....	17	2	Caldonia.....	Driver.....	Mine car.....	Caldonia.....	Rainbow Coal & M. Co.
Sept. 14.....	Samuel Shepherd.....	26	2	Sullivan.....	Miner.....	Falling slate.....	Union.....	Union Coal Co.
June 4.....	Perry Kirkham.....	23	3	In country.....	Miner.....	Falling slate.....	Bruliettes No. 6.....	Bruliettes Creek Coal Co.
Oct. 19.....	Mathew Gibson.....	21	21	In country.....	Miner.....	Falling slate.....	Bruliettes No. 6.....	Bruliettes Creek Coal Co.

VERMILION COUNTY.

Jan. 9.....	John Thompson.....	51	5	Clinton.....	Carpenter.....	Fell down shaft.....	Crown Hill No. 2.....	Crown Hill Coal Co.
Nov. 1.....	Mat Pugh.....	34	5	Clinton.....	Shooter.....	Smoke explosion.....	Rhodes.....	J. K. Rhodes Coal Co.
Dec. 30.....	Robert McClain.....	24	24	Clinton.....	Driver.....	Mine car.....	Willow Grove.....	Willow Grove Coal Co.

VIGO COUNTY.

March 14.....	Robert Cole.....	25	25	Heckland.....	Outside laborer.....	Fell off R. R. car.....	Diamond.....	Coal Bluff M. Co.
March 15.....	Oscar King.....	20	1	Grant.....	Miner.....	Powder explosion.....	Grant No. 2.....	Grant Coal & M. Co.
Sept. 17.....	Chas. Powell.....	21	1	Grant.....	Miner.....	Delayed shot.....	Grant No. 2.....	Grant Coal & M. Co.
Oct. 18.....	Peter Fedore.....	18	1	Heckland.....	Miner.....	Crushed, mine car.....	Diamond.....	Coal Bluff M. Co.
Nov. 28.....	John Deagneous.....	42	2	Ehrmindale.....	Miner.....	Falling slate.....	Klondike.....	Bruliettes Creek Coal Co.

TABLE,

Showing the Nationality of Persons Killed in and Around the Mines of Indiana the Year 1904. Also the Number of Persons Dependent on Them for Support.

NATIONALITY.	Fatalities.
American	25
English	1
Irish	1
Scotch	2
Welsh	1
Polander	1
Austrian	2
Colored	1
Total	34

COMPARATIVE TABLE,

Showing Number of Tons of Coal Mined Each Year, the Number of Persons Employed and the Number of Tons Produced Per Each Death from January 1, 1879, to January 1, 1905.

YEAR.	Tons Produced.	Employees.	Deaths.	Per Death.
1879	1,196,490	3,459	Not reported.	.....
1880	1,560,375	No report.	.....	.....
1881	1,771,536	4,567	.....	.....
1882	1,900,000	No report.	10	.....
1883	2,560,000	5,403	.....	.....
1884	2,260,000	5,716	11	.....
1885	2,375,000	6,502	9	.....
1886	3,000,000	6,406	7	.....
1887	3,217,711	No report.	.....	.....
1888	3,140,979	6,685	17	.....
1889 (No report) .....	.....	.....	.....	.....
1890	3,791,211	6,550	5	.....
1891	3,819,600	6,975	5	.....
1892	4,408,471	7,600	19	.....
1893	4,358,897	7,431	22	.....
1894 (No report) .....	.....	.....	.....	.....
1895	4,302,084	7,885	23	.....
1896	4,068,124	7,112	28	.....
1897	4,088,100	7,984	16	.....
1898	5,146,920	No report.	22	.....
1899	5,864,975	7,366	15	.....
1900	6,283,063	8,858	18	.....
1901	7,019,203	12,096	24	.....
1902	8,763,197	13,139	24	.....
1903	9,992,563	15,128	65	.....
1904	9,872,404	17,638	34	.....

TABLE OF SERIOUS ACCIDENTS.

CLAY COUNTY.

Date.	Name.	Occupation.	Injury.	Cause.	Mine.	Company.
Jan. 4.	Evan Powell.	Miner.	Collar bone broken.	Falling coal.	Lawrence No. 6.	Zellar-McClellan Co.
Jan. 20.	Leonard Cole.	Miner.	Leg broken.	Falling coal.	Lawrence No. 6.	Zellar-McClellan Co.
Feb. 2.	Albert Parker.	Miner.	Body bruised.	Falling slate.	Crawford No. 5.	Crawford Coal Co.
Feb. 10.	Marin Formento.	Driver.	Hip crushed.	Falling slate.	Brazil Block No. 9.	Brazil Block Coal Co.
Feb. 13.	Wm. Byson.	Miner.	Shoulder injured.	Falling slate.	Cloverland No. 1.	Zellar-McClellan Co.
Feb. 18.	David Riley.	Driver.	Foot crushed.	Mine car.	Cloverland No. 1.	Zellar-McClellan Co.
Feb. 18.	Perry Chaney.	Miner.	Face burned.	Explosion of powder.	Brazil Block No. 7.	Brazil Block Coal Co.
Mar. 8.	Wm. Carbon.	Miner.	Foot crushed.	Falling slate.	Cloverland No. 1.	Zellar-McClellan Co.
Mar. 12.	Antone Ceglader.	Miner.	Pelvis bone broken.	Falling slate.	Brazil Block No. 1.	Ind. Bituminous Coal Co.
Apr. 21.	Grant Duncan.	Machine run r.	Leg broken.	Crushed by mine car.	Pearl.	Brazil Block Coal Co.
May 4.	Charles Haines.	Miner.	Body bruised.	Machine & mine car.	Lewis.	Lewis Coal Co.
May 28.	Robert Baxter.	Driver.	Hip injured.	Went back on shot.	Gifford No. 1.	Collins Coal Co.
June 7.	Wm. Carbon.	Miner.	Head injured.	Falling slate.	Crawford No. 1.	Zellar-McClellan Co.
June 21.	Ed. Muncie.	Miner.	Leg injured.	Falling slate.	Cloverland No. 7.	Crawford Coal Co.
July 6.	J. W. Stoker.	Flat trimmer.	Head and shoulder injured.	R. R. car.	Cloverland No. 1.	Zellar-McClellan Co.
Aug. 31.	Wm. Irwin.	Day man.	Leg broken.	Falling slate.	Zellar-McClellan No. 4.	Zellar-McClellan Co.
	Sam. Butcher.	Driver.	Arm broken.	Mine car.	Brazil Block No. 9.	Brazil Block Coal Co.

DAVIESS COUNTY.

Date.	Name.	Occupation.	Injury.	Cause.	Mine.	Company.
Mar. 15.	Logan Fields.	Miner.	Leg broken.	Falling slate.	Montgomery No. 3.	Davies County Coal Co.
Aug. —	Frank Hurman.	Jerryman.	Foot crushed.	Falling slate.	Mutual.	Mutual Mining Co.

GIBSON COUNTY.

Date.	Name.	Occupation.	Injury.	Cause.	Mine.	Company.
Jan. 12.	Wm. Fine.	Miner.	Leg broken.	Delayed shot.	Oswald.	Princeton Mining Co.
Feb. 28.	Jeff Turfin.	Driver.	Hips and back injured.	Mine car.	Oswald.	Princeton Mining Co.

GREENE COUNTY.

Jan. 27.	Harry Myers.....	Miner.....	Shoulder fractured.....	Mine car.....	Midland.....	Midland Coal Co.
Jan. 8.	George Siasford.....	Driver.....	Ankle crushed.....	Mine car.....	Island Valley No. 4.....	Island Valley Coal Co.
Jan. 18.	John Thomas.....	Boss driver.....	Ankle crushed.....	Mine car.....	Lewis.....	Lewis Coal Co.
	Perry Wilson.....	Cager.....	Hips crushed.....	Mine car.....	Green Valley.....	Green Valley Coal Co.
	Cass Marion.....	Driver.....	Hips crushed.....	Mine car.....	Island Valley No. 3.....	Island Valley Coal Co.
Jan. 29.	R. H. Allen.....	Miner.....	Leg fractured.....	Falling coal.....	N. West.....	Northwest Coal Co.
Feb. 13.	Charles Phillips.....	Miner.....	Head and hip injured.....	Fall down shaft.....	Black Creek.....	Black Creek Coal Co.
Feb. 20.	Walter Fisher.....	Driver.....	Back injured.....	Mine car.....	Green Valley.....	Green Valley Coal Co.
Feb. 21.	Charles Matton.....	Driver.....	Crushed in abdomen.....	Mine car.....	Gilmour.....	Indiana Southern Coal Co.
Feb. 25.	H. L. Rector.....	Driver.....	Back injured.....	Mine car.....	Island No. 3.....	Island Coal Co.
Feb. 26.	John Hays.....	Driver.....	Two ribs broken.....	Falling slate.....	Victoria.....	Victoria Coal Co.
Feb. 28.	Al Redwell.....	Miner.....	Foot crushed.....	Falling coal.....	Gilmour.....	Indiana Southern Coal Co.
Mar. 8.	Jauner Wallace.....	Miner.....	Foot crushed.....	Falling slate.....	Lewis.....	Lewis Coal Co.
Apr. 1.	Aleck John.....	Machine helper.....	Rib fractured.....	Falling coal.....	Island Valley No. 3.....	Island Valley Coal Co.
Apr. 25.	Adam Deem.....	Driver.....	Two ribs broken.....	Mine car.....	Island No. 1.....	Island Coal Co.
July 25.	Chas. Stridman.....	Miner.....	Foot crushed.....	Falling slate.....	South Linton.....	South Linton Coal Co.
July 25.	Jack Miller.....	Driver.....	Hips injured.....	Falling coal.....	Victoria.....	Victoria Coal Co.
July 29.	E. Reddy.....	Driver.....	Leg crushed.....	Mine car.....	Green Valley.....	Green Valley Coal Co.
	W. Matron.....	Driver.....	Back injured.....	Mine car.....	Green Valley.....	Green Valley Coal Co.
	Wm. White.....	Driver.....	Finger cut off.....	Mine car.....	Green Valley.....	Green Valley Coal Co.
	Richard Lewis.....	Timberman.....	Leg broken.....	Falling slate.....	Gilmour.....	Gilmour Coal Co.
June 11.	John Camper.....	Driver.....	Arm broken.....	Mine car.....	Gilmour.....	L. T. Dickerson Coal Co.
June 20.	Jack Lunnham.....	Machine runner.....	Arm mangled.....	Mine and cage.....	Gilmour.....	Indiana Southern Coal Co.
June 30.	John Hughes.....	Driver.....	Side injured.....	Mining machine.....	Atlas No. 2.....	Johnson Coal Co.
May 3.	Lloyd James.....	Driver.....	Leg broken.....	Mine car.....	Gilmour.....	Indiana Southern Coal Co.
May 11.	Joe Suke.....	Miner.....	Total blindness.....	Mine car.....	Victoria.....	Victoria Coal Co.
	Wm. Wagner.....	Driver.....	Legs crushed.....	Back on shot.....	N. West.....	North West Coal Co.
Oct. 15.	John Flanski.....	Miner.....	Back injured.....	Mine car.....	Antioch.....	Antioch Coal Co.
Nov. 15.	Wm. Kinney.....	Miner.....	Collar bone broken.....	Falling coal.....	North West.....	North West Coal Co.
Dec. 7.	George Patton.....	Day man.....	Eyes injured.....	Falling slate.....	South Linton.....	South Linton Coal Co.
Dec. 7.	E. G. Shoplaw.....	Driver.....	Ankle broken.....	Premature shot.....	Lewis.....	Coal Bluff Mining Co.
Dec. 7.	Oto Larboe.....	Cager.....	Leg broken.....	Mine car.....	Summit No. 2.....	Summit Coal Co.
Dec. 10.	Walker Benfrom.....	Miner.....	Leg broken.....	Falling slate.....	Midland.....	Midland Coal Co.
					Atlas No. 1.....	Johnson Coal Co.

KNOX COUNTY.

July 22.	Pat Ryan.....	Miner.....	Breast and face burned.....	Premature shot.....	Bicknell.....	Blacknell Coal Co.
Feb. 10.	Sam Price.....	Miner.....	Three ribs broken.....	Falling slate.....	Prospect Hill.....	Prospect Hill Coal Co.

TABLE OF SERIOUS ACCIDENTS—Continued.

PARKE COUNTY.

Date.	Name.	Occupation.	Injury.	Cause.	Mine.	Company.
Jan. 14.	Otto Powers.	Miner.	Rib broken.	Falling slate.	Minshall No. 1.	Minshall Vein Coal Co.
Feb. 16.	Martin Fermento.	Driver.	Chest injured.	Falling slate.	B. B. Coal Co. No. 9.	B. B. Coal Co.
Feb. 22.	Kago Dottie.	Driver.	Arm broken.	Between car and prop.	Lyford No. 1.	Lincoln Coal and Mining Co.
Mar. 16.	George Jaco.	Miner.	Face and arms burned.	Explosion of powder.	Lyford No. 1.	Lincoln Coal and Mining Co.
Mar. 17.	John Keller.	Driver.	Foot crushed.	Mine car.	Minshall No. 1.	Minshall Vein Coal Co.
Feb. 27.	James Houky.	Miner.	Back injured.	Falling slate.	Lyford No. 1.	Parke County Coal Co.
Mar. 8.	Lee Whier.	Machine run'er.	Finger mashed off.	Machine jack and rib.	Park No. 11.	Lincoln Coal and Mining Co.
Apr. 29.	Joe Carzetta.	Miner.	Spine injured.	Falling slate.	Gilmour.	Zellar-McClellan Coal Co.
June 22.	Wm. Oswald.	Machine helper.	Hip injured.	Falling slate.	Brazil Block No. 12.	Brazil Block Coal Co.
July 18.	Joe Woods.	Loader.	Nose broken.	Falling slate.	Mecca No. 3.	Mecca Coal and Mining Co.
Aug. 25.	Mike Papincak.	Miner.	Face and head injured.	Falling slate.	Brazil Block No. 9.	Brazil Block Coal Co.
Aug. 27.	Marion Yowel.	Miner.	Arm broken.	Falling slate.	Minshall No. 1.	Minshall Vein Coal Co.
Aug. 29.	Brant McAblester.	Miner.	Shoulder injured.	Falling slate.	Minshall No. 2.	Minshall Vein Coal Co.
.....	Mike Gentle.	Miner.	Leg broken.	Falling slate.	Superior No. 3.	Zellar-McClellan Co.
Aug. 31.	Wm. Erbine.	Miner.	Leg broken, back injured.	Falling slate.	Superior No. 4.	Lincoln Coal and Mining Co.
Sept. 8.	Manuel Hatt.	Driver.	Hips injured.	Falling slate.	Lyford No. 1.	Lincoln Coal and Mining Co.
Oct. 20.	Essich Hawkins.	Miner.	Body bruised and burned.	Blown out shot.	Lyford No. 1.	Lincoln Coal and Mining Co.

PIKE COUNTY.

Date.	Name.	Occupation.	Injury.	Cause.	Mine.	Company.
Jan. 13.	Alley Hall.	Miner.	Face and body burned.	Powder explosion.	Carbon.	Aberdeen Coal Co.
Jan. 14.	Rice Kullang.	Miner.	Finger crushed off.	Mine car.	Petersburg.	Muncie Coal and Mining Co.
Jan. 25.	Ben Allen.	Miner.	Thumb cut off.	Falling slate.	Hartwell.	S. H. Wulfman.
Sept. 8.	Mulburn Little.	Ass't mine boss.	Ankle bone fractured.	Mine car.	Blackburn.	S. W. Little Coal Co.
Feb. 10.	Chris Edes.	Miner.	Back injured.	Falling slate.	Winslow.	Winslow Gas Coal Co.
Mar. 23.	John King.	Day man.	Shoulder fractured.	Fell against prop.	Ayrshire.	Ayrshire Coal Co.
Dec. 3.	J. B. Milley.	Mine boss.	Ankle fractured.	Mine car.	Blackburn.	S. W. Little Coal Co.

SULLIVAN COUNTY.

Date.	Name.	Occupation.	Injury.	Cause.	Mine.	Company.
Jan. 5.	Moses White.	Miner.	Face and hands burned.	Dust explosion.	Mammoth Vein.	Mammoth Vein Coal Co.
Jan. 21.	Wm. Stavenon.	Miner.	Back injured.	Falling slate.	Mildred.	J. Woolley Coal Co.
Feb. 3.	Victor Sharp.	Miner.	Face and head injured.	Falling coal.	Cummins.	Cummins Coal Co.
.....	Rose White.	Miner.	Face and head injured.	Falling slate.	Caladonia.	Rainbow Coal & Mining Co.
.....	A. Pierson.	Driver.	Three ribs dislocated.	Mine car.	Mildred.	J. Woolley Coal Co.

Mar. 24.	Marsh Moore	Driver.	Jawbone crushed.	Kicked by mule.	Cummins.	Cummins Coal Co.
Mar. 16.	Thomas James.	Driver.	Foot crushed.	Mine car.	Star City.	Harder-Hafer Coal Co.
Mar. 18.	Jack N. Arthur.	Miner.	Leg broken.	Falling coal.	Phoenix No. 3.	New Pittsburg Coal & Coke Co.
Apr. 7.	Charles Young.	Miner.	Arm dislocated.	Falling coal.	St. Clair.	Ind. Hooking Coal Co.
Apr. 13.	J. H. Wooley.	Mine boss.	Leg broken.	Fell off mine car.	Star City.	Harder-Hafer Coal Co.
Apr. 23.	Jacob Week.	Driver.	Shoulder dislocated.	Fell off mine car.	Star City.	Harder-Hafer Coal Co.
May 26.	Wm. Epperson.	Mine boss.	Toe broken.	Falling slate.	Green Hill.	Green Hill Coal Co.
June 1.	Ross Nixon.	Track layer.	Back injured.	Falling slate.	St. Clair.	Ind. Hooking Coal Co.
May 21.	Jas. Lindsay.	Driver.	Shoulder dislocated.	Falling slate.	Phoenix No. 1.	New Pittsburg Coal Co.
July 14.	J. M. Peor.	Cager.	Elbow fractured.	Coal fell from cage.	Freeman.	Sullivan Coal Co.
Aug. 17.	John Crynes.	Miner.	Injured internally.	Falling slate.	Star City.	Harder-Hafer Coal Co.
Sept. 10.	Chas. McGarvey.	Loader.	Back crushed.	Falling slate.	Wilfred.	Wilfred Coal Co.
Sept. 14.	Stephen Harper.	Timberman.	Collar bone broken.	Falling slate.	Union.	Union Coal Co.
Dec. 6.	Fred Ring.	Driver.	Hip dislocated.	Mine car.	Jackson Hill No. 2.	Jackson Hill Coal & Coke Co.
Dec. 7.	Lonie Delania.	Miner.	Skull fractured.	Premature blast.	Mammoth Vein.	Mammoth Vein Coal Co.

VANDERBURGH COUNTY.

Feb. 11.	J. Killeue.	Miner.	Shoulder fractured.	Falling slate.	Unity.	Crescent Coal Co.
Aug. 11.	Hugh Monahan.	Miner.	Rib broken.	Fell from scaffold.	Ingleside.	Ohio River Coal Co.
Dec. 30.	Joe Brown.	Driver.	Knee injured.	Mine car.	Sunnyside.	Sunnyside Coal Co.

VERMILLION COUNTY.

Jan. 4.	John Mahon.	Miner.	Skull fractured, one eye out.	Crushed by cage.	Bruliettes Creek No. 3.	Bruliettes Creek Coal Co.
Jan. 9.	Oliver Green.	Miner.	Hand and face burned.	Dust explosion.	Atherton.	Chas. F. Keeler Coal Co.
Jan. 9.	Wm. Jones.	Miner.	Face and head burned.	Same accident.	Atherton.	Chas. F. Keeler Coal Co.
Jan. 27.	Wm. Clements.	Driver.	Foot broken.	Mine car.	Bruliettes Creek No. 3.	Bruliettes Creek Coal Co.
Feb. 1.	Mike Wagner.	Miner.	Collar bone broken.	Mine car.	Prince.	Kellar Coal Co.
Mar. 3.	Shill Webster.	Driver.	Hips injured.	Mine car.	Buckeye.	McClellan Sons & Co.
Apr. 20.	Harry Livengood.	Cager.	Back injured.	Coal falling down shaft.	Buckeye.	McClellan Sons & Co.
Aug. 5.	Robert Thomas.	Miner.	Leg fractured.	Falling slate.	Eureka No. 1.	Cayuga Pressed Brick Co.
Sept. 8.	Manna Hatt.	Driver.	Back injured.	Mine car.	Lyford No. 1.	Lincoln Coal & Min. Co.
Sept. 20.	Judson Rice.	Dumper.	Leg broken.	Falling slate.	Bruliettes Creek No. 6.	Indiana Fuel Co.
Oct. 23.	James Jackson.	Driver.	Shock by electricity.	Falling slate.	Prince.	Kellar Coal Co.
Oct. 23.	H. Littlehale.	Miner.	Leg broken.	Mine cage.	Buckeye.	McClellan Sons & Co.
Oct. 23.	Ed. Bishop.	Miner.	Collar bone broken.	Mine cage.	Buckeye.	McClellan Sons & Co.
Oct. 23.	John Galloway.	Miner.	Back injured.	Mine cage.	Buckeye.	McClellan Sons & Co.
Oct. 23.	George Swinford.	Miner.	Knee injured.	Smoke explosion.	Eureka.	Cayuga Brick and Coal Co.
Nov. 15.	Wm. Dummer.	Miner.	Burned externally.	Same accident.	Eureka.	Cayuga Brick and Coal Co.
Nov. 15.	Lester Jones.	Miner.	Burned externally.	Same accident.	Eureka.	Cayuga Brick and Coal Co.

TABLE OF SERIOUS ACCIDENTS—Continued.

VIGO COUNTY.

Date.	Name.	Occupation.	Injury.	Cause.	Mine.	Company.
Jan. 6	Oran Hicks	Miner	Back injured.	Falling slate.	Diamond	Coal Bluff Mining Co.
Jan. —	Alonzo Morris	Miner	Leg broken.	Fell off cage.	Seeleyville No. 2	Seeleyville Coal & Mining Co.
Feb. —	Tom McKinney	Miner	Face and hands burned	Premature blast.	Union	Coal Bluff Mining Co.
Feb. —	Vene Tanner	Miner	Face and breast burned	Shot exploded while tamping.	Broadhurst	Home Coal Co.
Feb. 23	John Hamilton	Driver	Hips fractured.	Falling under car.	Glen Oak	Glen Oak Coal Co.
Feb. 24	Henry Triple	Miner	Burned internally.	Misplaced shot.	Grant No. 2	Grant Coal Co.
Mar. 15	Oscar King	Miner	Burned internally.	Explosion of powder	Grant No. 2	Grant Coal Co.
Mar. 19	Arch West	Miner	Face and hands burned	Explosion of powder	Seeleyville No. 2	Seeleyville Coal Co.
Mar. 23	B. Waugh	Driver	Lost an eye.	Kicked by mule.	Glen Oak	Glen Oak Coal Co.
Apr. 13	William Shepherd	Driver	Leg broken.	Mine car.	Miami No. 2	Miami Coal Co.
Apr. 23	Abe Akers	Driver	Crushed in chest.	Mine car.	Lawton	Coal Bluff Mining Co.
July —	Richard Christopher	Miner	Both legs broken.	Falling slate.	Miami No. 2	Miami Coal Co.
July 8	Fred Christman	Miner	Wrist broken	Falling coal.	Miami No. 1	Miami Coal Co.
July 20	Albert Regan	Driver	Shoulder dislocated.	Mine car.	Hacktor	Laughlin Coal Co.
Aug. —	John Co-bip	Miner	Wrist fractured.	Mine car.	Peerless	Fauvre Coal Co.
Aug. 23	Benjamin Moore	Miner	Spine injured	Descending cage.	Fauvre	Fauvre Coal Co.
Sept. 14	William Garrett	Miner	Lost one eye.	By blast.	Atherton	Chas. F. Kellar Coal Co.
Aug. 17	Frank Adams	Miner	Ankle broken	Mine car.	Diamond	Coal Bluff Mining Co.
Oct. 15	Burton Gideon	Miner	Collar bone fractured	Falling coal.	Fauvre	Fauvre Coal Co.

WARRICK COUNTY.

Date.	Name.	Occupation.	Injury.	Cause.	Mine.	Company.
Mar. 10	Thomas Jones	Miner	Ankle injured.	Falling slate.	Electric	L. D. Seales.
Dec. 15	William Law	Miner	Injured internally.	Premature shot.	Star No 2	Ohio River Coal Co.

NOTE. The above includes those who have sustained broken bones, injury to spine, internal injuries, cuts, bruises and other injuries, such as we think require special mention.

ACCIDENTS TO MINE PROPERTY.

Considering the increased number of new mines in operation during the past year, the financial loss from accidents to mine property for that period were comparably small. The most serious accident occurring, and one that entailed the greatest financial loss, was the destruction of the entire surface plant of the Coal Bluff Mining Company's Glen No. 2 Mine, in the early part of November, by fire. The loss of buildings, ropes, cages, screens, scales and repairs on machinery, boilers, etc., from the accident will probably amount to \$10,000.

On Saturday night, October 29th, a fire, originating from a blast, occurred at the face of one of the cross-entries in the Atlas No. 1 Mine, in Greene County. The fire was not discovered until the following Monday morning, and it had gained such headway, owing to the dense volume of smoke and gases given off, that the mine could not be operated. Two days were lost, during which time air-tight brattices were built across the entry and in the breakthroughs for the purpose of smothering the fire, after which operations were resumed. The loss from this accident, other than the time lost by the mine being idle, would not exceed \$150.

A gob fire, originating from spontaneous combustion, occurred in the Midland Mine about December 5th. Prompt action on the part of the mine management in effectively sealing off the affected galleries with air-tight brattices, built of brick and mortar, prevented it from assuming serious proportions, and on my visit to the mine, December 12th, the fire was under complete control. The cost of material, labor, etc., in constructing the brattices will amount to about \$1,000. In addition to this a considerable portion of the mine will be abandoned for the present.

A fire originating from a gas blower being lighted by a blast occurred at the face of one of the working places in the Citizens' Mine, in Sullivan County. Fortunately, the mine was located near the waterworks in the town of Sullivan, and through the aid of the fire department from that town the fire was extinguished after about twelve hours' labor. The loss from this accident will not exceed \$100.

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RECORD OF STATE GEOLOGY.

On December 13th, about 6:15 p. m., one of the boilers in the Park No. 10 Mine plant exploded with great violence. So great was the force of the explosion that several other boilers located near the one that exploded were thrown out of position, and all of the smokestacks except one were knocked down and the boiler room completely wrecked. Fortunately there was no one seriously injured, although several workmen were in the near vicinity when the boiler gave way.

The excessive heavy rainfall during the latter part of the winter and early spring flooded a number of mines in different parts of the State. Considering the time the mines were idle while the water was being pumped out, the repairs, etc., necessary to put them in shape for operation, the damage suffered from this was probably greater than from any other cause during the year. Among those whose loss was the greatest are the following:

The Buckeye Mine, in Greene County, was flooded March 11th, and remained idle until June 1st.

The Island No. 1 and Island Valley No. 3 were both flooded on the same date, and were idle two weeks.

The Blackburn Mine, in Pike County, was also flooded about the same date, and has not been operated since that time.

The Bruillette's Creek No. 3, in Vermillion County, was flooded about March 20th, and was idle about one month.

The Chicago No. 6 Mine, in Vigo County, was flooded in February, and did not resume operations until August.

The Klondike Mine, in Vigo County, was flooded in March, and did not resume operations until July.

Names and addresses of persons operating mines in each county, also the names of the mines:

CLAY COUNTY.

Name.	Address.	Mine.
Brazil Block Coal Company.....	Brazil.....	Brazil Block No. 1.
Brazil Block Coal Company.....	Brazil.....	Brazil Block No. 4.
Brazil Block Coal Company.....	Brazil.....	Brazil Block No. 8.
Brazil Block Coal Company.....	Brazil.....	Gart No. 7.
Brazil Block Coal Company.....	Brazil.....	Gart No. 10.
Continental Clay & Mining Co.....	Brazil.....	Continental No. 1.
I. S. & R. McIntosh Coal Co.....	Brazil.....	Rebstock.
Zellar-McClellan & Co.....	Brazil.....	Cloverland No. 1.
Zellar-McClellan & Co.....	Brazil.....	Cloverland No. 2.
Zellar-McClellan & Co.....	Brazil.....	Superior No. 4.
Zellar-McClellan & Co.....	Brazil.....	Superior No. 7.
Indiana Bituminous Coal Co.....	Terre Haute.....	Fairview.
Indiana Bituminous Coal Co.....	Terre Haute.....	Pearl.
Jackson Coal & Mining Co.....	Brazil.....	Cornwall.
Crawford Coal Company.....	Brazil.....	Crawford No. 5.
Crawford Coal Company.....	Brazil.....	Crawford No. 4.
Crawford Coal Company.....	Brazil.....	Crawford No. 6.
Crawford Coal Company.....	Brazil.....	Crawford No. 8.
Crawford Coal Company.....	Brazil.....	Crawford No. 9.
Star Union Coal & Oil Co.....	Indianapolis.....	Fortner.
C. Ehrlich Coal Company.....	Turner.....	Klondike.
Collins Coal Company.....	Brazil.....	Gifford No. 1.
Collins Coal Company.....	Brazil.....	Gifford No. 2.
American Clay Mfg. Company.....	Brazil.....	Monarch.
Lewis Coal & Mining Company.....	Lewis.....	Lewis.
Vivian Coal Company.....	Chicago.....	Vivian No. 4.
Vivian Coal Company.....	Chicago.....	Vivian No. 5.
Indiana Block Coal Company.....	Saline.....	Lower Vein Block No. 1.
Jasonville Coal Company.....	Jasonville.....	Gold Knob.
Dan Davis Coal Co.....	Brazil.....	Worlds Fair No. 2.
Island Valley Coal Co.....	Linton.....	Island Valley No. 4.

DAVISS COUNTY.

Stucky & Osborn.....	Raglesville.....	Stuckey.
Daviss County Coal Co.....	Montgomery.....	Montgomery No. 3.
Mutual Mining Company.....	Cannelburg.....	Mutual.
Winklepleck & Overton.....	Raglesville.....	Union.
Mandabach Bros.....	Washington.....	Mandabach.

FOUNTAIN COUNTY.

Rush Coal Company.....	Cleveland, Ohio.....	Rush.
Silverwood Coal Company.....	Silverwood.....	Silverwood.

GIBSON COUNTY.

Princeton Coal & Mining Co.....	Princeton.....	Oswald.
Massey Coal Company.....	Oakland City.....	Massey.
Fort Branch Coal Company.....	Fort Branch.....	Fort Branch.

GREENE COUNTY.

Name.	Address.	Mine.
Black Creek Coal Company.....	Linton	Black Creek.
Island Coal Company	Indianapolis.....	Island No. 1.
Island Coal Company	Indianapolis.....	Island No. 2.
Island Coal Company	Indianapolis.....	Island No. 3.
Island Coal Company	Indianapolis.....	Island No. 5.
Indiana Southern Coal Co.....	Chicago	Gilmour.
Hoosier Coal Company	Bloomfield	Hoosier No. 1.
Hoosier Coal Company	Bloomfield	Hoosier No. 2.
Island Valley Coal Company.....	Linton	Island Valley No. 2.
Island Valley Coal Company.....	Linton	Island Valley No. 3.
South Linton Coal Company.....	Linton	South Linton.
Midland Coal Company.....	Midland.....	Midland.
Vulcan Coal Company	Indianapolis.....	Vulcan.
Summit Coal Company	Bloomfield	Summit No. 2.
Western Indiana Coal Co.....	Terre Haute	Templeton.
Victoria Coal Company	Linton	Victoria.
L. T. Dickason Coal Co.....	Linton	Glenburn.
Antioch Coal Company.....	Linton	Antioch.
Tower Hill Coal Company.....	Bloomington.....	Tower Hill.
Green Valley Coal Company.....	Jasonville	Green Valley.
Lattas Creek Coal Company.....	Terre Haute	Lattas Creek No. 1.
Johnson Coal Company.....	Columbus, Ohio.....	Atlas No. 1.
Johnson Coal Company.....	Columbus, Ohio.....	Atlas No. 2.
Crouch Coal Company.....	Jasonville	Fry.
Letsinger Coal Company.....	Bloomfield.....	Letsinger.
Northwestern Coal Company.....	Jasonville.....	Northwestern.
Coal Bluff Mining Co.....	Terre Haute	Twin.
North Linton Coal Company.....	Linton	North Linton.
Pennsylvania & Indiana Coal Co.	Midland.....	Pennsylvania.

KNOX COUNTY.

Bicknell Coal Company.....	Bicknell	Bicknell.
Knox Coal Company	Bicknell	Knox.
Lynn Coal Company.....	Bicknell	Lynn.
Sugar Loaf Mining Co.....	Bicknell	Prospect Hill.
Enterprise Coal Company.....	Vincennes.....	Enterprise.
Washington-Wheatland Coal Co.	Washington.....	Wheatland.
Chicago & Big Muddy Coal Co.	Bicknell	Pine Knot.

PARKE COUNTY.

W. P. Harrison	Rockville	Harrison.
Brazil Block Coal Co.....	Brazil	Brazil Block No. 12.
Brazil Block Coal Co.....	Brazil	Cox No. 3.
Brazil Block Coal Co.....	Brazil	Brazil Block No. 9.
Rock Run Coal Co.....	Mecca	Lucia.
Mecca Coal & Mining Co.....	Mecca	Mecca No. 3.
Lincoln Coal & Mining Co.....	Chicago, Ill.....	Lyford No. 1.
Otter Creek Coal Co.....	Chicago, Ill.....	Mary.
Zellar-McClellan & Co.....	Brazil	Superior No. 1.
Zellar-McClellan & Co.....	Brazil	Superior No. 2.
Zellar-McClellan & Co.....	Brazil	Superior No. 3.
Minshall Vein Coal & Mining Co.	Terre Haute	Minshall No. 1.
Minshall Vein Coal & Mining Co.	Terre Haute	Minshall No. 2.
Plymouth Block Coal Co.....	Terre Haute	Pan American.
Continental Coal Co.....	Terre Haute	Raccoon.
Parke County Coal Co.....	Rosedale	Parke No. 11.
Parke County Coal Co.....	Rosedale	Parke No. 12.

PERRY COUNTY.

Bergonroth Bros.....	Troy	Troy.
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PIKE COUNTY.

Name.	Address.	Mine.
Aberdeen Coal Company	Carbon	Aberdeen.
Ingle Coal Company	Oakland City	Ayrshire No. 3.
Aberdeen Coal Company	Carbon	Carbon.
Ingle Coal Company	Oakland City	Ayrshire No. 4.
Ingle Coal Company	Oakland City	Ayrshire No. 5.
Ingle Coal Company	Oakland City	Ayrshire No. 6.
S. W. Little Coal Company	Evansville	Rogers.
S. W. Little Coal Company	Evansville	Blackburn.
S. W. Little Coal Company	Evansville	Littles.
S. H. Wulfman	Huntingburg	Partwell.
Muncie Coal & Mining Co	Muncie	Petersburg.
Winslow Gas Coal Co.	Winslow	Winslow No. 2.
Winslow Gas Coal Co.	Winslow	Winslow No. 5.

SULLIVAN COUNTY.

Washington Fuel Co.	Chicago, Ill.	Bunker Hill.
Rainbow Coal & Mining Co	Caladonia	Caladonia.
Indiana & Chicago Coal Co	Chicago, Ill.	Dugger.
Green Hill Coal Co.	Sullivan	Green Hill.
Hymers Coal Co.	Hymers	Hymers No. 2.
Hymers Coal Co.	Hymers	Hymers No. 3.
Hymers Coal Co.	Hymers	Hymers No. 4.
New Linton Coal Co.	Indianapolis	New Linton.
Jackson Hill Coal & Mining Co	Terre Haute	Jackson Hill No. 2.
New Pittsburg Coal & Coke Co.	Chicago, Ill.	Phoenix No. 1.
New Pittsburg Coal & Coke Co.	Chicago, Ill.	Phoenix No. 3.
New Pittsburg Coal & Coke Co.	Chicago, Ill.	Phoenix No. 4.
Keystone Coal Co.	Chicago, Ill.	Shelburn.
Harder-Hafer Coal Co	Chicago, Ill.	Star City.
Sullivan County Coal Co.	Hymers	White Ash.
Sullivan County Coal Co.	Hymers	Freeman.
Sun Flower Coal Co.	Dugger	Sun Flower.
W. S. Bogle Coal & Mining Co	Chicago, Ill.	Glendora.
Wilfred Coal Co.	Shelburn	Wilfred No. 1.
Island Coal Co.	Indianapolis	Island No. 4.
Linton Semi Block Coal Co	Linton	Wolford.
Cummins Coal Co.	Chicago, Ill.	Cummins.
Indiana Hocking Coal Co	Farmersburg	La Blanche.
Citizens' Coal Co.	Sullivan	Citizens.
Bruiettes Creek Coal Co.	Terre Haute	Bruiettes Creek No. 6.
J. Woolley Coal Co.	Evansville	Mildred.
Keller Coal Co.	Chicago, Ill.	Virginia.
Superior Coal Co.	Terre Haute	Superior.
Coal Bluff Mining Co.	Terre Haute	Shirley Hill.
Coal Bluff Mining Co.	Terre Haute	Little Giant.
N. Jackson Hill Coal & M. Co.	Shelburn	St. Clair.
Kettle Creek Coal Co.	Shelburn	Kettle Creek.
Reliance Coal Co.	Sullivan	Reliance.
Union Coal Co.	Sullivan	Union.
Linton Bituminous Coal Co.	Linton	Hamilton.

VANDERBURGH COUNTY.

Diamond Coal Company	Evansville	Diamond.
C. Thomas Coal Company	Evansville	First Avenue.
Ingle Coal Company	Evansville	Ingle.
Sunnyside Coal Company	Evansville	Sunnyside.
Evansville Coal & Mining Co	Evansville	Union.
Crescent Coal Company	Evansville	Unity.

VERMILLION COUNTY.

Name.	Address.	Mine.
Brillettes Creek Coal Co.....	Terre Haute.....	Brillettes Creek No. 3.
Indiana Fuel Company.....	Clinton.....	Brillettes Creek No. 5.
Indiana Fuel Company.....	Clinton.....	Riverside.
Cayuga Press Brick Company.....	Cayuga.....	Eureka.
McClellan & Sons.....	Clinton.....	Buckeye.
Clinton Coal Company.....	Clinton.....	Crown Hill No. 1.
Clinton Coal Company.....	Clinton.....	Crown Hill No. 2.
Oak Hill Coal & Mining Co.....	Clinton.....	Oak Hill.
Keller Coal Company.....	Clinton.....	Prince.
Willow Grove Coal Company.....	Clinton.....	Willow Grove.
J. K. Deering & Co.....	Chicago, Ill.....	Rhodes.
Maple Valley Coal Company.....	Clinton.....	Maple Valley No. 1.
Maple Valley Coal Company.....	Clinton.....	Maple Valley No. 2.

VIGO COUNTY.

Chas. F. Keeler Coal Company.....	Chicago, Ill.....	Atherton.
Terre Haute Brick & Pipe Co.....	Terre Haute.....	Brick Works.
Manufactures Fuel Co.....	Chicago, Ill.....	Chicago No. 6.
Coal Bluff Mining Company.....	Terre Haute.....	Diamond.
Coal Bluff Mining Company.....	Terre Haute.....	Peerless.
Brillettes Creek Coal Company.....	Terre Haute.....	Lawton.
J. Ehrlich.....	Seeleyville.....	Klondike.
Grant Coal Company.....	Grant.....	Seeleyville.
W. S. Bogle Coal & Mining Co.....	Chicago, Ill.....	Grant No. 2.
Loughner Coal Company.....	Seeleyville.....	Glen Oak.
Miami Coal Company.....	Brazil.....	Hector.
Miami Coal Company.....	Brazil.....	Miami No. 1.
Miami Coal Company.....	Brazil.....	Miami No. 2.
Parke County Coal Company.....	Rosedale.....	Miami No. 3.
Parke County Coal Company.....	Indianapolis.....	Parke No. 10.
Seeleyville Coal & Mining Co.....	Seeleyville.....	Redbird.
Seeleyville Coal & Mining Co.....	Seeleyville.....	Rosebud No. 2.
West Terre Haute Coal Co.....	West Terre Haute.....	Royal.
Home Coal Company.....	West Terre Haute.....	Larimer.
Deep Vein Coal Company.....	Terre Haute.....	Broadhurst.
Green Field Coal & Mining Co.....	Terre Haute.....	Deep Vein.
L. T. Dickason Coal Co.....	Indianapolis.....	Greenfield No. 1.
Sugar Creek Coal Company.....	Terre Haute.....	Lost Creek.
Vigo County Coal Company.....	Seeleyville.....	Sugar Creek.
Forrest Park Coal Company.....	Terre Haute.....	Ray No. 2.
		Forrest Park.

WARRICK COUNTY.

Hall & Marsh.....	Chandler.....	Air Line.
Big Four Coal Company.....	Boonville.....	Big Four.
J. Woolley Coal Company.....	Boonville.....	Big Vein No. 3.
J. A. Bryan.....	Evansville.....	Chandler.
Charles Menden.....	Evansville.....	De Forrest.
John Archibald.....	Evansville.....	Star No. 1.
T. D. Scales Coal Company.....	Boonville.....	Electric.
Ohio River Coal Company.....	Evansville.....	Burke.

Names and addresses of mine bosses and names of mines which they are managing.

CLAY COUNTY.

Name.	Address.	Name of Mine.
John Bolin.....	Brazil.....	Brazil Block No. 1.
William Rosser.....	Diamond.....	Brazil Block No. 8.
B. F. Jenkins.....	Brazil.....	Gart No. 7.
William Woods.....	Diamond.....	Gart No. 10.
Samuel Holden.....	Brazil.....	Continental.
John Jenkins.....	Brazil.....	Rebstock.
Fred Eberwine.....	Cloverland.....	Cloverland No. 1.
George Myers.....	Brazil.....	Cloverland No. 2.
Thomas Thompson.....	Brazil.....	Lawrence No. 6.
William Myers.....	Turner.....	Fairview.
Moses Marks.....	Caradonia.....	Cornwall.
Griff Howell.....	Centerpoint.....	Crawford No. 5.
Walter Knox.....	Asherville.....	Crawford No. 6.
Eli Tibits.....	Turner.....	Fortner.
Jacob Ehrlich.....	Staunton.....	Klondike.
George A. Davis.....	Brazil.....	Gifford No. 1.
August Norkus.....	Brazil.....	Gifford No. 2.
H. W. Jenkins.....	Brazil.....	Glen No. 1.
H. W. Jenkins.....	Brazil.....	Glen No. 2.
Edward Somers.....	Staunton.....	Pearl.
Alexander Ferguson.....	Coalmont.....	Lewis.
William Johnson.....	Jasonville.....	Vivian No. 4.
William Johnson.....	Jasonville.....	Vivian No. 5.
William Perry.....	Brazil.....	Crawford No. 8.
William Risher.....	Saline.....	Lower Vein No. 1.
W. G. Spears.....	Brazil.....	Crawford No. 9.
Joseph C. Winn.....	Brazil.....	Brazil No. 4.
William Miller.....	Brazil.....	Superior No. 4.
Wilson McIntire.....	Jasonville.....	Gold Knob.
William Pence.....	Brazil.....	World's Fair.
James Skene.....	Brazil.....	Crawford No. 4.

DAVIESS COUNTY.

Arnold Brown.....	Montgomery.....	Montgomery No. 3.
J. P. Jager.....	Cannelburg.....	Mutual.
W. A. Jacobs.....	Raglesville.....	Union.
Jacob Mandabach.....	Washington.....	Mandabach.

FOUNTAIN COUNTY.

William Perry.....	Cates.....	Rush.
J. S. Tiley.....	Silverwood.....	Silverwood.

GIBSON COUNTY.

William Woods.....	Princeton.....	Oswald.
John Odell.....	Fort Branch.....	Fort Branch.

GREENE COUNTY.

Name.	Address.	Name of Mine.
Reuben Small.....	Linton.....	Black Creek.
Richard Potter.....	Linton.....	Island No. 1.
Winn Risher.....	Linton.....	Island No. 2.
Henry Osha.....	Linton.....	Island No. 3.
Charles Vaughn.....	Linton.....	Island No. 4.
James Scully.....	Gilmour.....	Gilmour.
James Meredith.....	Linton.....	Hoozier No. 1.
Joseph Ferry.....	Linton.....	Hoozier No. 2.
George Epperson.....	Linton.....	Island Valley No. 2.
Joseph Fennel.....	Linton.....	Island Valley No. 3.
John Randall.....	Linton.....	South Linton.
William Davidson.....	Midland.....	Midland.
James Gibson.....	Linton.....	Vulcan.
William McQuade.....	Linton.....	Summit No. 2.
Joseph Dunkerly.....	Linton.....	Templeton.
W. Badders.....	Linton.....	Victoria.
John Kelley.....	Linton.....	Glenburn.
James Stevenson.....	Linton.....	Antioch.
John McQuade.....	Midland.....	Tower Hill.
William James.....	Jasonville.....	Green Valley.
Thomas Hyatt.....	Jasonville.....	Lattas Creek.
Ira Dalrymple.....	Linton.....	Atlas No. 1.
James Pascoe.....	Linton.....	Atlas No. 2.
William Crouch.....	Jasonville.....	Fry.
Dan Davis.....	Jasonville.....	Letsinger.
James Templeton.....	Linton.....	Twin.
William Stevenson.....	Linton.....	North Linton.
Frank Lockhart.....	Linton.....	Pennsylvania.

KNOX COUNTY.

R. M. Freeman.....	Bicknell.....	Bicknell.
William Lynn.....	Bicknell.....	Knox.
E. G. Hooper.....	Bicknell.....	Lynn.
Samuel Price.....	Vincennes.....	Prospect Hill.
Harvey Conrod.....	Bicknell.....	Enterprise.
Thomas Harris.....	Washington.....	Wheatland.
William J. Brown.....	Bicknell.....	Pine Knot.

PARKE COUNTY.

W. P. Harrison.....	Rockville.....	Harrison.
Charles Doidge.....	Diamond.....	Brazil Block No. 12.
George Doidge.....	Coxville.....	Cox No. 3.
James Lamb.....	Montezuma.....	Lucia.
Harry Milburn.....	Lyford.....	Lyford No. 1.
John Chesterfield.....	Brazil.....	Mary.
Thomas Maxwell.....	Brazil.....	Superior No. 1.
Daniel Isaac.....	Brazil.....	Superior No. 2.
James Cuthbertson.....	Brazil.....	Superior No. 3.
Robert Monkhouse.....	Jessup.....	Minshall No. 1.
Matt Raffle.....	Jessup.....	Minshall No. 2.
John T. Sommers.....	Carbon.....	Pan-American.
James Coakley.....	Diamond.....	Brazil Block No. 9.
Thomas Karrick.....	Coxville.....	Raccoon.
D. N. Williams.....	Rosedale.....	Parke No. 11.
George Lindsay.....	Mecca.....	Mecca No. 4.

PERRY COUNTY.

William Bergenroth.....	Troy.....	Troy.
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PIKE COUNTY.

Name.	Address.	Name of Mine.
John Jones.....	Ayrshire.....	Aberdeen.
Bart Stinson.....	Ayrshire.....	Ayrshire No. 3.
W. L. Smith.....	Ayrshire.....	Ayrshire No. 4.
John Willie.....	Petersburg.....	Blackburn.
John Willie.....	Petersburg.....	Rogers.
Herman Rose.....	Little.....	Little.
Bart Stinson.....	Ayrshire.....	Ayrshire No. 5.
George Briggs.....	Cabel.....	Hartwell.
John O. Johnson.....	Sophia.....	Carbon.
John Jenkins.....	Winslow.....	Winslow No. 1.
John Jenkins.....	Winslow.....	Winslow No. 5.

SULLIVAN COUNTY.

J. V. Gustin.....	Farnsworth.....	Bunker Hill.
Murry Bledsoe.....	Caladonia.....	Caladonia.
W. F. Asbell.....	Dugger.....	Dugger.
Harry Evans.....	Sullivan.....	Green Hill.
Asa Roberts.....	Hymers.....	Hymers No. 4.
John Griffith.....	Dugger.....	New Linton.
J. H. Needhammer.....	Jackson Hill.....	Jackson Hill No. 2.
George Sargent.....	Alum Cave.....	Phoenix No. 1.
Alexander Faulds.....	Alum Cave.....	Phoenix No. 3.
William Dempsey.....	Shelburn.....	Shelburn.
I. H. Woolley.....	Del Carbo.....	Star City.
William Green.....	Hymers.....	White Ash.
O. H. Hendrickson.....	Dugger.....	Freeman.
Thomas Lehman.....	Dugger.....	Sun Flower.
Walter Phillips.....	Sullivan.....	Glendora.
Joseph Peters.....	Hymers.....	Hymers No. 2.
Edward Newport.....	Shelburn.....	Wilfred No. 1.
David Love.....	Dugger.....	Island No. 4.
James Taylor.....	Shelburn.....	Mammoth Vein.
William Jackson.....	Linton.....	Little Giant.
R. Sharp.....	Cummins.....	Cummins.
John D. Price.....	Farmersburg.....	La Blanche.
James Nolan.....	Sullivan.....	Citizens.
Ed. Shirkie.....	Farmersburg.....	Bruliettes Creek No. 6.
John McCloud.....	Sullivan.....	Mildred.
John Jordan.....	Sullivan.....	Virginia.
William Vanhorn.....	Farmersburg.....	Superior.
John Quigley.....	Linton.....	Shirley Hill.
Jacob Eck.....	Farmersburg.....	St. Clair.
A. Moreland.....	Jackson Hill.....	Jackson Hill No. 4.
Theodore Thompson.....	Hymers.....	Hymers No. 3.
A. L. Boyer.....	Shelburn.....	Kettle Creek.
A. D. Scott.....	Sullivan.....	Reliance.
James Stewart.....	Shelburn.....	Phoenix No. 4.
Martin Navin.....	Sullivan.....	Union.

VANDERBURG COUNTY.

Adolph Becker.....	Evansville.....	Diamond.
Frank Gunther.....	Evansville.....	First Avenue.
James Johnson.....	Evansville.....	Ingliside.
James Anderson.....	Evansville.....	Sunnyside.
Pius Schulthius.....	Evansville.....	Union.
C. H. Baetz.....	Evansville.....	Unity.

VERMILLION COUNTY.

Name.	Address.	Name of Mine.
Thomas McQuade	Clinton.....	Bruilettes Creek No. 3.
Richard Moore.....	Clinton.....	Bruilettes Creek No. 5.
Thomas Rose.....	Clinton.....	Buckeye.
R. M. Irwin.....	Cayuga.....	Eureka.
Claud Peck.....	Clinton.....	Crown Hill No. 1.
D. W. James.....	Clinton.....	Crown Hill No. 2.
William Hutchinson.....	Clinton.....	Oak Hill.
Frank Christy.....	Clinton.....	Prince.
Nick Walker.....	Clinton.....	Willow Grove.
William Wilson.....	Clinton.....	Rhodes.
A. P. Gilmoure.....	Clinton.....	Riverside.
J. W. Walker.....	Clinton.....	Maple Valley No. 1.
J. W. Walker.....	Clinton.....	Maple Valley No. 2.

VIGO COUNTY.

James Sidell.....	Atherton.....	Atherton.
Art Thompson.....	Terre Haute.....	Brick Works.
James Markham.....	Coal Bluff.....	Chicago No. 6.
James McGow.....	Burnett.....	Diamond.
Charles Long.....	Coal Bluff.....	Peerless.
John Cain.....	Burnett.....	Lawton.
Wesley Alvis.....	Seeleyville.....	Seeleyville.
W. F. Decker.....	Burnett.....	Grant No. 2.
H. E. Wilson.....	Burnett.....	Glen Oak.
B. B. Barnett.....	Seeleyville.....	Hector.
James Beskill.....	Ehrmindale.....	Klondike.
James Barker.....	Brazil.....	Miami No. 1.
Thomas Bingham.....	Rosedale.....	Parke No. 10.
James Hawkins.....	West Terre Haute.....	Redbird.
J. D. Lewis.....	Seeleyville.....	Rosebud No. 2.
John Scott.....	Seeleyville.....	Royal.
Eli Eller.....	West Terre Haute.....	Larimer.
William L. Erwin.....	West Terre Haute.....	Broadhurst.
W. J. Urwin.....	Brazil.....	Miami No. 2.
Richard Morgan.....	West Terre Haute.....	Deep Vein.
Josiah Pedlar.....	West Terre Haute.....	Greenfield No. 1.
Henry Payne.....	Seeleyville.....	Lost Creek.
George Doney.....	West Terre Haute.....	Sugar Creek.
George West.....	Seeleyville.....	Ray No. 2.
James Burt.....	Cloverland.....	Miami No. 3.
John Gilmour.....	Terre Haute.....	Forrest Park.

WARRICK COUNTY.

T. B. Hall.....	Chandler.....	Air Line.
John E. Kelley.....	Boonville.....	Big Four.
P. F. Hargrove.....	Boonville.....	Big Vein No. 3.
John McCain.....	Chandler.....	Chandler.
M. Wilson.....	De Forrest.....	De Forrest.
Edwin Archbald.....	Newburg.....	Star No. 1.
William Mason.....	Boonville.....	Electric.
H. P. Kasemeir.....	Newburg.....	Burke.

ANNUAL REPORT OF THE STATE NATURAL GAS SUPERVISOR.

OFFICE OF STATE NATURAL GAS SUPERVISOR,
MARION, IND., February 15, 1905.

Prof. W. S. Blatchley, State Geologist:

DEAR SIR: I have the honor to submit to you herewith my second annual report as State Natural Gas Supervisor, covering the calendar year of 1904, and being the thirteenth annual report from this department. The gas field has undergone a series of changes in the past year, and new conditions are confronting the producers. It has been impossible for me to collect and compile a report containing all the data regarding the field as it exists at the present time. In view of this, I have dwelt upon those conditions which will be of most importance to those in the preservation of the natural gas industry.

I trust the report will receive your approval and be found worthy of consideration by the public.

BRYCE A. KINNEY,
State Natural Gas Supervisor.

ANNUAL REPORT OF THE STATE NATURAL GAS SUPERVISOR.

All persons interested in the production of natural gas throughout the State of Indiana are more or less familiar with the laws governing the production and consumption of this natural product, as well as the law enacted by the State Legislature creating the office of State Natural Gas Supervisor and defining his duties.

Laws are made to conform to and govern existing conditions. As conditions change they necessitate the extension, modification or conformation of the laws applicable. Likewise the change of conditions has caused the attention of this office to be directed in somewhat different channels than formerly. Former reports from this office have undoubtedly given in a general way the exact conditions of the field. Owing to the radical change in conditions, such reports will be cited only by way of comparison. It shall be my purpose in this report to give more of the data regarding the condition of the field; also, the dangers which threaten to lessen, if not make it impossible, to produce this great natural resource.

The law provides that it shall be the duty of the State Natural Gas Supervisor to make a personal inspection of all gas wells of the State as far as practicable; to see that every precaution is taken to insure the health and safety of the workmen engaged in opening gas wells, laying mains and pipes, and also the safety of those who in any manner use natural gas for mechanical, manufacturing, domestic or other purposes. Today only skilled workmen are employed by contractors, gas companies and manufacturers; hence these duties require little attention from this office.

This office is also required to incorporate in this annual report to the State Geologist complete and tabulated statistics of the number of gas wells, with their location and record of geological strata passed through in drilling them, the volume of gas pro-

duced, the rock pressure, the increase or decrease in rock pressure and volume flow, the number of miles, capacity and cost of mains laid; the cost of gas as fuel; the number of persons employed in the production of gas. Much of this information is published by the Bureau of Statistics; besides, some of it is not relevant to the demands of today. I inspect a sufficient number of wells to gain correct ideas as to the condition of the gas supply. The inspection of pipe lines once each year, or as often as the State Geologist may require, is only partially necessary, since all of the larger gas companies employ men to inspect their lines regularly. In general the public realize the limitation of our gas supply, and less of the supervisor's time is demanded in the enforcement of this branch of the law, although there are some who have no conception of the value or supply of gas, and seem to think it inexhaustible. The general public must come to the realization of the fact that the natural gas must be husbanded, or the supply will soon be exhausted. As a means towards this saving, the introduction of the meter system has been a great factor. The most important duties required of this office at present are to see that laws of the State pertaining to the drilling and plugging of wells and the consumption of gas are enforced. As the field develops and the territory extends the duties of this office become greater in proportion with this development. Wells that five years ago were considered worthless and plugged are now considered good, and every precaution is taken to preserve and prolong their life. Much trouble is caused by the rusting and decay of mains and the iron in these old wells. This office has given constant attention to wastes of this nature. Five years ago four good wells would supply a city of twelve thousand with fuel; today it requires fifty wells, and then the supply is limited, although the consumers are more careful than formerly.

Oil and gas interests are in a way opposed to each other, yet the same dangers threaten both, as will be shown in another chapter of this report. Certain oil operators have shown a disposition to disregard the laws provided for the production of the gas product, and the number of prosecutions against oil operators for waste of gas have been greater than last year. Other operators conform strictly to the law, and realize that they have barely

enough gas to provide fuel for the leases, and although a heavy gas pressure interferes with the production of oil, there is no necessity of wasting the gas to enhance the oil production, for the reason that the gas can be turned into the mains of the gas companies, who are always ready to purchase it at a fair price. It is now the opinion of experienced oil and gas men that if the supply is as carefully husbanded in the future as during the last year that we will have gas for several years to come.

One year ago gas waste threatened to exhaust the gas supply. Today it is the introduction of fresh water into the gas rock that menaces both the oil and gas industry. If the existing laws prescribing the manner in which wells shall be plugged are complied with, it is a sufficient protection against this evil as from the wells that are now abandoned. There has been a disposition on the part of some to disregard this law, and it has been impossible for the Supervisor or his deputies to be present at all times when wells were plugged for the reason that they had no notice of the intention of the operator to abandon the well. In the main prosecutions for a failure to comply with the provisions of this law have been against people who have no permanent interest in the field. Those who have producing properties understand the necessity of properly plugging abandoned wells, and exercise great care in this regard for the preservation of their own property. The attention of this office has been earnestly directed to this portion of its duties. I have endeavored to do that which would be of most importance to oil and gas interests under present conditions.

CONDITION OF THE GAS FIELD.

Today the condition of the gas field is so varied and so constantly changing that to make an intelligent report is very difficult. During the early history of the field the conditions were almost uniform, and examination of one or more sections gave an idea of the condition of the entire field. To gain any knowledge of all of the field and of the gas supply at this time it is necessary to visit and examine each section of the field, as well as to understand the general character and location of the gas rock. In this field Trenton limestone is referred to as gas rock, while in truth

only a small part of Trenton limestone is gas rock. Only the porous part of Trenton limestone is gas rock, as it alone has the textural formation necessary to a gas reservoir. It is found within the Trenton formation, cropping out on either surface. It is usually found from one to fifteen feet below the upper surface of the Trenton rock and is from one to fifty feet thick. In a few instances the vein has been found deeper, but there is rarely over fifty feet of continuous gas rock. Both surfaces of the rock are very irregular, and in no instance has the surface been found level for any considerable distance. A relief map of the surface, as shown in Prof. Blatchley's report of 1903, would show many elevations and depressions.

The early history of the field showed similar conditions throughout the entire gas area, which remained the same until the advancing salt water met the lower portions of the overlying strata of hard limestone, permeating and completely occupying the lowest parts of the gas rock. The higher parts of the gas rock have been completely shut off from each other as the gas has been consumed and as the salt water has advanced. Thus instead of being one immense gas reservoir, as there was for years, there are numerous independent reservoirs, each completely sealed by the salt water. The life of the gas in each independent reservoir depends upon the height and breadth of the elevation, the porosity of the rock and the consumption of gas. As the supply of gas diminishes and the salt water advances, the reservoirs from which we now obtain our gas will be divided and subdivided into smaller reservoirs, until the supply is exhausted. If, in drilling, one of these elevations or small reservoirs is struck, a "gusher" is reported, and, conversely, if a depression is struck, the result is obvious.

The above explains the reason for the great difference in the life, rock pressure and volume of gas produced by wells located in the same field. Often wells on the same farm show a great variation in the rock pressure and volume of flow. One may produce gas in commercially valuable quantities for six months, while another may fill up with salt water within a week.

Another element with which the gas field has to contend is the oil industry. The progress of this industry and its effect upon the gas industry will be treated in another chapter of this report.

As stated in former reports, the last few years have developed peculiarities and differences from previous years in the history of natural gas. For the first few years after the discovery of gas there was little systematic drilling. Wells were drilled when and where they were needed; no attention was paid to waste, and every city and town was supplied with an abundance of gas. Within a few years after its discovery pipe line companies entered the field and the drilling and development became systematic. The different parts of the field were connected. Pipe line companies, gas companies and manufacturers soon realized that they would have to lease territory to hold as a reserve for future development, and also to plan their field of operation. The larger gas companies endeavored to gain control of the entire field. This failed because the highways could not be pre-empted, and wherever a gas company could gain a right of way for a pipe line enough well sites could be acquired without much trouble. From the beginning pipe lines have been extended, year after year, toward what was considered the center of the field. When possible, wells were drilled one-half mile apart, although the distance has never been uniform; sometimes small areas contiguous to pipe lines were undeveloped. After this nothing remained but for the companies to re-drill their territory. With only a few exceptions the drilling done during the year was on locations between old wells, nearly all of which had been drilled years ago. The per cent. of failures is increasing yearly, and when gas is found the flow is seldom over 500,000 cubic feet, and frequently below this. Today wells are considered good that a few years ago, when the production was at its highest point, would have been considered failures.

Although the wells obtained today are small, still, they are profitable. Gas today sells for five times as much as it did ten years ago. The cost of a well is rarely more than the cost of drilling, as all the iron is generally taken from abandoned wells. Much of the gas territory is becoming oil territory, and the wells are not a loss, although gas is not discovered.

ABANDONED TERRITORY.

Many of the larger gas companies have abandoned much of their territory, pulled their wells and disposed of their leases to oil companies, as much of the abandoned gas territory is now producing oil. The Lafayette Gas Company has done no drilling in the past year. They have pulled twenty-five or more wells, and their pressure has depreciated in the last year from an average of from seven to twenty pounds to from three to zero at the present time.

The Logansport and Wabash Valley Gas Company have pulled about forty wells, and have entirely abandoned the Logansport division of their company, having taken up all pipe lines and abandoned all the wells.

The Indiana Gas Company has pulled fifteen wells, has made no extension and has done no drilling in the past year. The best pressure that they have is from three to three and one-half pounds, with the exception of three or four wells being located in what is known as the Sheridan field, which is in the southern edge of Tipton County. These wells have a comparatively high pressure, but a great amount of water and very little gas.

The Consumers' Gas Company, whose properties were located near Fairmount, and between Alexandria and Indianapolis, have practically abandoned all of their wells and sold their properties to oil companies for oil development.

NEW TERRITORY.

The Barnes Gas Company, of Marion, have drilled fifteen wells in the last year, with an average rock pressure of one hundred pounds and an average volume of 200,000 cubic feet to each well. The best well was drilled during the month of December, 1903, on the Edward Goldthwaite farm, one mile east of Marion. This well started with a volume of 500,000 cubic feet, and is now making 50,000 cubic feet. The following is the record of this well:

Drive pipe	160 feet.
Casing	420 feet.
Top of Trenton.....	873 feet.
Total depth	887 feet.

A deep well was drilled on the William Amsden farm, located in Center Township, Grant County, in which gas was struck at a depth of 280 feet in the Trenton. A volume of water came into the hole before reaching this depth. As yet they have been unable to exhaust the water, and consequently the well is not producing gas at this time. The gas coming up through 600 feet of water showed a pressure of several pounds; however, no correct test of the well has been made. The record of this well is as follows:

Drive pipe	140 feet.
Casing	440 feet.
Top of Trenton.....	900 feet.
Total depth	1,297 feet.

Four good gas wells were drilled on the William Boxwell lease, located four miles northeast of Marion, in Washington Township, Grant County. These wells were drilled into the Trenton to a depth of about sixty-five feet, showing an average rock pressure of one hundred pounds and a volume of 250,000 cubic feet.

On December 8, 1904, a well was completed on the Flora Evans lease, located in the southwest quarter of section 14, in Bear Creek Township, Jay County, showing a rock pressure of 350 pounds. No correct test has been made of the volume. The record of this well is as follows:

Drive pipe	303 feet.
Casing	387 feet.
Top of Trenton	988 feet.
Total depth	1,060 feet.

About thirty wells have been drilled in the vicinity of Knightstown during the past year. These wells have been drilled by local companies, and show a rock pressure of about 70 pounds, with an average volume of about 200,000 cubic feet. The average record of these wells is as follows:

Drive pipe	85 feet.
Casing	390 feet.
Total depth	950 feet.

GIBSON COUNTY OIL AND GAS FIELD.

During the year 1904 there have been about forty-five gas and oil wells drilled in the vicinity of Princeton, in Patoka Township, Gibson County. The average record of these wells is as follows:

Drive pipe	100 feet.
Casing	600 feet.
Total depth	870-910 feet.

One of these wells was completed on the Dixon lease during the month of July, 1904, by the Ohio Oil Company, and developed a rock pressure of 310 pounds, with a volume of 600,000 feet when completed. It now shows a rock pressure of 260 pounds and a volume of 100,000 feet. This well was drilled to the depth of 872 feet. Another well was drilled in the same vicinity on the Miller lease, which developed a rock pressure of 300 pounds and a volume of 800,000 feet. The rock pressure of this well is now about 260 pounds and the volume 100,000 cubic feet. Two wells were drilled on the Knight lease by the Southern Oil Company. No. 1 developed a volume of 600,000 cubic feet and No. 2 a volume of 400,000 cubic feet.

All of the foregoing wells are located in the vicinity of Princeton, which city has been faring well in the way of gas. Their glass factory is being operated at its full capacity, and its residents are well supplied with gas for fuel. Almost all of the oil wells produce more or less gas. The gas product from the oil wells is used for operating the leases, and the balance, if any, is turned into the gas mains of the gas companies. While the gas product in the vicinity of Princeton is very satisfactory at the present time, the history of the field will, in all probability, be a repetition of that at Loogootee, where the conditions were practically the same.

THE CONSUMPTION OF GAS.

The consumption of natural gas has not decreased as much during the past year as it did during the year of 1903. While it is true that a number of gas companies have abandoned their properties and ceased operating, other companies have done considerable drilling and have succeeded in keeping their production from ma-

terial depreciation. All the gas companies sell their gas by meter measurement. Under this system of measurement the companies receive about five times as much for their gas as they did under the flat rate system. In general the consumers do not rely wholly upon gas as a fuel during the colder months, yet they still continue to use it in connection with other fuel. Thus the use of natural gas for domestic purposes is about the same as it was during the year 1903.

It is impossible to say how much gas is used for manufacturing purposes. A number of the factories have not shut off the gas entirely, but continue to use it during the summer months. But few factories will leave the gas field for the reason that the supply is becoming less. The majority of the more substantial factories in the field are supplementing the limited supply of gas with other fuel. It is impossible to say how long the gas supply will last. It is the opinion of experienced gas men that under the present system of measurement and consumption it will last for a considerable length of time. All the cities that were using gas during the year 1903 have continued the use of same with one exception. The city of Indianapolis has entirely abandoned the use of natural gas as a fuel.

WASTE OF GAS.

It is hardly necessary to say anything about this subject, for the reason that it has been thoroughly gone over in the report of 1903 and the conditions are now practically the same as during that year. Most of the waste can be charged to carelessness in the way of imperfect fittings and improper burners. While it is true that it is difficult to produce oil from a well with a high gas pressure without wasting gas, the present pressure is at a point where oil can be produced with little difficulty. There are numerous localities in the oil field where the gas is so scarce that the operator has trouble in obtaining sufficient gas with which to operate the leases. If there is a surplus, it can be turned into low-pressure gas mains of gas companies at a fair compensation. By experience I have ascertained the sections where the disposition to waste gas seems greatest, and, by constant attention, I have re-

duced the waste of gas to a minimum. Of course, it is only by constant attention that waste of gas can be prevented as long as any remains in the mains.

PLUGGING OF ABANDONED GAS AND OIL WELLS.

Another element with which the gas industry has had to contend is the introduction of fresh water into the oil and gas rock from wells that have been improperly plugged, or, as is often the case, not plugged at all. This is an evil which, at the present time, seriously threatens the oil and gas industry throughout the State. Much has been done to enforce the law regarding the plugging of gas and oil wells. The condition of the field at the present time shows that this subject needs constant attention. This condition, although new to the Indiana field, is not new to old and experienced operators, for the same conditions have developed in the Eastern fields, after a failure to plug the numerous abandoned wells. Valuable properties have been rendered valueless in this way. As far as I have been able, together with my assistants, I have constantly directed the attention of this office to this phase of its duties. It has been impossible, under existing conditions, for a representative from this office to be present in person at all times when wells are plugged. While the more responsible operators have vigorously complied with the provisions of the law, still, there are numerous wells throughout the State that have been improperly plugged or not plugged at all, as is evidenced by the vast amount of fresh water which is being pumped from oil wells in certain localities in the field.

COMPRESSING STATIONS.

The annual report from this office for the year 1901 says: "With the decrease in the rock pressure in the field came the necessity for using compressors on pipe lines. The pressure required to transport natural gas depends primarily upon the consumption. With no consumption, and the pipe line perfectly tight, the pressure at the outlet of the line must be the same as at the wells, and with the line wide open at the point of consumption the loss of pressure is at a maximum. The amount of natural

gas that can be transported in any pipe line a given distance depends upon the size of the line and the pressure in the same, the former governing the volume of gas and the latter the velocity. Thus, as the field pressure decreases the question presented to both gas companies and manufacturers is whether to build compressing stations or increase their pipe line capacity. Some have adopted the former, others the latter, while occasionally it has been necessary to resort to both." Some of the gas companies have installed compressors during the year 1904, while others have either reduced the capacity of their compressors or abandoned the gas industry altogether.

The Huntington Light and Fuel Company have established a new compressing station near Upland. This station was started in the month of November, 1904. They obtained their gas supply from the Upland, Matthews, Gas City and Marion fields, and have a capacity capable of supplying 20,000 people. The station at Upland is one of the best in the field.

The Ft. Wayne Gas Company has established a new compressing station near Anderson. This station draws its gas supply from the territory south and southeast of Anderson and from the territory near Frankton and Pendleton. This station possesses a capacity equal to that of the Huntington Light and Fuel Company, but it is doubtful if their supply is as great as that of the former company.

The Chicago Gas Company has removed about one-half of their compressors at their Fairmount and Greentown stations. The Lafayette Gas Company has reduced the capacity of their station, located at Summitville, in the same proportion. The reduction of the capacity at the above-mentioned stations has been due to the fact that their gas supply has been considerably diminished.

The Princeon Natural Gas Company and the Petersburg Natural Gas Company have not, as yet, established compressing stations. They continue to rely on the rock pressure to furnish a sufficient supply of gas to the consumers. Their supply, as stated by Prof. Blatchley, in his annual report of 1903, is obtained from the Huron sandstone, and the wells are not as long-lived as those of the Trenton limestone field. The above-named companies will, in all probability, be compelled to establish compressing stations

within the next year. The production from the Loogootee field, in Martin County, has diminished considerably. The area of the field remains practically the same as in the year 1903.

I have tested the pressure in all of the lines transporting gas from the larger and more powerful compressors, and have not found the pressure to be above 200 pounds at any time.

THE UTILIZATION OF CONVICT LABOR IN MAKING ROAD MATERIAL.

BY W. S. BLATCHLEY.

The question of good roads is at present one of the most vital with which the farming community of Indiana has to deal. Many of the better counties of the State long ago realized the importance of this question, and, where the road material was conveniently located, constructed gravel or macadam roads radiating in all directions from their county towns. In other counties possessing a plentiful supply of road material the importance of the question has not yet been realized, and for six months of the year the farmers are practically isolated from market, or, if they manage to reach it once a week, can only haul thereto a fraction of a load. Such counties are readily recognized as far below the average in wealth, prosperity and the public spirit of their citizens.

Prof. Latta, of Purdue University, a few years ago made a careful study of the good roads question in the State. He received reports from hundreds of farmers, some of whom live on good roads once bad and others on roads still bad. From these reports he computed statistics showing that the difference between good and bad roads amounts to 78 cents an acre annually on the farms. Apply this amount to the entire State—36,350 square miles, or 23,264,000 acres—and we have the sum of \$18,145,920. Of this amount fully two-thirds is wasted every year in the State in the loss of time and in the loss of opportunity in securing the best market for the produce of the farm.

This question of good and bad roads came up to me very forcibly in the past year while writing a paper on the petroleum industry of Indiana. In preparing a map for that paper I found that many farms in the very center of productive territory had not been drilled because they were on mud roads and distant from railway stations. The iron drive pipe, casing and tubing and th

derrick timbers necessary for drilling in and pumping a productive well are very heavy, and it is almost impossible to haul them over many of the roads in the oil field between the 1st of November and the 1st of April. The operator, therefore, develops first those leases on pike roads or close to railway stations, leaving those on mud roads to the very last. The farmers living in the oil belt who are receiving or might receive large sums in royalty for their oil should, therefore, see to it that their farms are accessible at all times. A successful oil operator is usually a busy man, who does not wish to lose 5-12 of his time on account of bad roads; hence, he leaves the territory with mud roads and operates that which he can reach 365 days in the year.

During the past decade our vehicles for rapid country travel have become more numerous and of an entirely different style from what they were twenty years ago. Almost every farmer now owns his own buggy and carriage. The bicycle by countless thousands has come to stay, and the automobile will soon be more common on the improved roads of the State than the two-horse s Surrey was a dozen years ago. The owners of all these forms of vehicles are demanding, and will continue to demand, better roads, and the legislator must soon learn that the question is one of the most important which he has to face.

Another phase of the good roads question came into existence with the twentieth century. Five years ago the rural mail carrier was an almost unknown factor in our State. Now he travels in every county, carrying his messages of joy or sorrow to the farmer's door each day. The daily paper, with its market reports and news of the world is, or can be, put regularly into the farmers' hands within a dozen hours of its issue, even though he lives a score of miles from a railway. Time is the most valuable possession given to man on earth, provided he has the ability and cares to use it to his advantage. The time saved in going to town for the mail or for some necessity which the mail carrier can bring is the most important advantage of the rural free delivery system. But this system will not, cannot and should not be made a permanent factor in the country unless the farmers see to it that the roads are kept in such a condition that the route can be covered in the time allotted. The United States Government, through its

Postoffice Department, demands that the farmers do this much, and the demand is just. Those farmers of the State who have had the foresight and good judgment to improve the roads in their vicinity are, for the most part, contented and prosperous. Their products are easily gotten to market when the price is at its best, and the wolf never rests on his haunches before their doors.

On the other hand, those living in the bad road districts endure, for more than a third of their time, an enforced idleness, which makes them ever poorer and causes them to cry out against their lot in life, rather than against their own short-sightedness on the road question. Indiana is rich in clay suitable for vitrified brick, rich in gravel, rich in stone for macadam roads. There is no reason, therefore, why every public road of any importance in the State should not be improved, so that it may be traveled with ease any day in the year.

Let us now take up a second phase of the question. In the penitentiary at Michigan City and in the Reformatory at Jeffersonville are 1,800 men, most of whom are able-bodied. Only a few years ago half of those in the Michigan City prison were being marched about to furnish them exercise, because the labor organizations of our State were opposed to their competition. The industry of the honest citizens of the State paid for maintaining these criminals in idleness. Even at the present time, under the contract system there in vogue, the prisoners at Michigan City are making shirts and socks in competition with sweat shops, and it may be said that prison industry has the general effect of degrading free industry in the same lines to the sweat-shop basis. The making of hollow ware, chairs, brooms, barrels, leather goods, etc., by the prisons of this and other States has had a killing effect on these industries. The convict contract system does conflict with free labor and free industry, and the agitation against it cannot and will not cease until it is thoroughly abolished.

Taking up the third phase of the question, we find that there is at present, in a number of the counties of Western and Southern Indiana, vast undeveloped deposits of shale and fire clay which, by numerous tests, have been proven suitable in every respect for the making of the best grade of paving brick and sewer pipe. Beneath most of these shale beds and overlying the fire

clay are thick beds of coal, far more than sufficient to burn the brick and pipe. The presence of this fuel is a point of great advantage, as it reduces the cost of the manufacture of the clay products to the lowest possible figure. In many counties, especially in the northern part of the State, there is an absence of gravel, stone or other material suitable for the improvement of the roads.

Knowing the presence of these raw road materials in inexhaustible quantities, and having a knowledge also of the crying necessity on the part of the public for better roads, as well as the demand from all labor organizations for the abolishment of the contract labor system among our convicts, I proposed, a few years ago, the following plan for utilizing convict labor for the public good in the lasting improvement of our roadways.

Let the General Assembly authorize the purchase of an extensive bed of shale in Western Indiana, and the erection on it of a modern paving brick factory. Equip this factory with convict labor and put several hundred additional convicts to breaking stone for foundation and cutting it for curbing. This brick and stone can then be furnished at the plant at less than one-sixth present prices to those counties devoid of other road material, or may be given them if they are not willing to buy it. The cost of a paving brick plant, completed for work, which has a capacity of 40,000 output per day, is about \$55,000. One with double the capacity costs about \$70,000. The greater amount of this expense is for buildings and kilns, which could, by convict labor, be constructed of brick made on the spot, so that the cost to the State would be less than half this sum. After the plant is once in operation, with fuel and raw material both at hand, the only outlay is for labor. Where the daily output is 80,000 brick, and the fuel is mined in connection with the shale, the number of hands necessary is about 100. These, at \$1.50 each per day, would make the cost of the brick about \$2.25 per thousand. With convict labor, the actual cost of the brick would only be the sum paid out for the maintenance of the prisoners. It costs 40 cents a day to maintain a convict. To this add 50 per cent. for wear and tear on tools, etc., and the cost would not exceed 60 cents a day. A year's output would be sufficient to pave 125 miles of roadway.

There are 42 brick to a square yard of roadway, and 503,000 to a mile of roadway 20 feet wide. The cost of this brick by convict labor would thus be \$300. The crushed stone necessary for macadam could be prepared by convict labor within the prison and furnished for not more than 30 cents per cubic yard, and the curbing at a correspondingly low price. In California the cost of macadam made by convicts is 25 cents a cubic yard. Prisoners in Massachusetts are making it at 28 cents. One mile of roadway 20 feet wide will require 1,304 yards of macadam to make a foundation four inches thick, or a total cost of \$365, at 28 cents a yard. Adding this to the cost of the brick makes the cost of the *material* for one mile of road \$665.

Next comes the cost of transportation from the prison to the point where needed. The railroads of Indiana would doubtless co-operate in any plan of systematic road building, as they have done in Illinois, California and other States. In California, where there is but one railroad company, and that credited with being hostile to the interests of the people, the material is transported from a State convict plant at the bare cost of haulage, the rate being 25 cents a ton for a haul of 100 miles. Good roads are important tributaries to railroads, and this accounts for their readiness to assist in making them. At 25 cents a ton it would cost \$625 to transport the brick and \$326 to transport the macadam for one mile of road 20 feet wide. Adding this to the cost of materials gives \$1,612.12 as the cost of materials on board cars at the point of use.

The cost of grading, curbing and laying need not exceed \$600 a mile. The cost of teaming varies. For an average distance of two and a half miles it is 30 cents per yard for macadam. The cost of hauling the brick and macadam, based on these figures, would be \$900. Therefore the cost of the brick road, aside from the cost of the materials, would be about \$1,500, or about one-half the total cost of the road, materials and all. It is the general statement of engineers that the cost of materials is about one-half the cost of a road.

A road of vitrified brick, which, if properly constructed, will last a half-century or longer, with little expense for maintenance, can then be built at a cost of not over \$3,300 a mile, the most of

which would be for teaming, grading and the laying of the brick. For, understand, the plan proposed does not consider that the convicts be employed except in the preparation of the material, the latter to be furnished free to the counties. All grading, teaming, bricklaying, etc., should be done by free labor, as it is at present. The day of the chain-gang at work on the roadside, subjected to the gaze and jeers of the passerby, is, rightfully, a thing of the past.

Not only could brick and macadam be made for roadways in the prison which I have in mind, but all brick, both ordinary and pressed front, could be made for all public buildings, such as jails, courthouses, schoolhouses, insane asylums and county infirmaries. The shale and fire clay is in every way suitable for such material, and it could be furnished at cost, which would not be over \$1.50 per thousand for the finest of pressed brick. The public pay the taxes to erect such buildings, and also the taxes for maintaining the prisoners; why not, then, have those prisoners prepare the material for public buildings and so lessen the tax burden of the people.

A few years ago California was in the same situation as Indiana is today. Her convicts were idle in deference to the wishes of her labor organizations. Her legislators passed a law authorizing the employment of the convicts in the breaking of stone for road material. Today that State is supplying the prepared stone to the counties at 28 cents a cubic yard on board the cars, which is less than one-third the ordinary market price; yet sufficient to pay for the maintenance of the convicts. The railroads of the State are carrying the material at the bare cost of hauling, for they realize that the improved country roads will bring to them in the future a great increase in farm products for shipment.

Many objections to the plan will doubtless arise, for the questions to be solved are important ones, and for that reason no plan can or will be presented but what will have its weak points. The most serious of these objections is the cost of a new prison, which would necessarily have to be constructed at the plant. This, however, would be much less than is generally supposed, since the shale can be burned into ordinary and pressed front brick of the

finest quality. The brick could therefore be made and constructed by the convicts themselves at a very reason

It seems, therefore, that, given an ever-growing demand for better roads, an abundance of nature's products which can be made into the best of road material, and a large number of convicts able and willing to work, we have a combination which, with the proper management, would give us the improved rural employment for our convict labor, and yet give us a new army of honest workmen whose interests and welfare would ever to be upheld.

In accordance with the above plan, the following bill was drafted in this office, and, in February, 1903, was introduced into the Lower House of the Sixty-third General Assembly. The bills, however, had the preference and support of the majority, but that be," and the one herewith presented was not reported by the committee.

A BILL FOR AN ACT abolishing contract labor in the Indiana Reformatory; creating a new Industrial Prison in the western part of the State; giving employment to convicts from the Reformatory at Jeffersonville; regulating the hours of labor, and how said labor shall be employed; making an appropriation for the purchase of land, tools, and other appliances necessary for the State to employ such convicts; providing for the public account system in the manufacture of vitrified brick and other material for the building of public highways; providing for superintendent, guards, etc., and declaring an emergency.

Section 1. *Be it enacted by the General Assembly of the State of Indiana:* That the employment of convict labor in competition with free labor in the Indiana Reformatory at Jeffersonville is hereby abolished. Convicts in said Reformatory shall not be hereafter employed on contracts other than those already made, which contracts shall be renewed when they expire.

Sec. 2. That the Governor of Indiana shall, on or before the first of April, 1903, appoint four competent and disinterested men, more than two of whom shall be of the same political party; these men shall constitute a Board of Control for a new Industrial Prison. Said Board of the Board of Control shall meet within ten days after the appointment, and shall immediately, by lot, determine the term of years each shall serve, as follows: One for one year, one for two years, one for three years and one for four years from the date of their appointment. Upon the expiration of the term of any member, the Governor shall appoint his successor for a term of four years. The Governor shall fill any vacancy which may at any time occur on the Board by death, resignation or other cause. The Board of Control, so constituted,

shall have the full management of the Industrial Prison, hereinafter to be provided for, up to the time when it shall be ready for the permanent occupancy by prisoners, when they shall appoint a General Superintendent or Warden, who shall have the same powers as does the present warden of the Indiana State Prison at Michigan City; and thereafter said Board of Control shall direct the management of said Industrial Prison in such a manner as will best aid the purposes for which it is created, or in such a manner as shall be hereafter provided by law. Each member of the Board of Control shall receive \$500 per annum in full for all salary and expenses.

Sec. 3. That the said Board of Control of the Industrial Prison is hereby authorized and empowered to purchase one thousand acres of land in western Indiana, at a sum not to exceed \$50 per acre; said land to be within reasonable switching distances of two or more different lines of railway; the greater portion of the surface of said land to be tillable, and to be underlain with shale or fire-clay suitable for making vitrified and ordinary brick; and at least two-thirds of said land to be underlain with one or more veins of workable coal, the minimum thickness of one vein of which shall be three feet.

Sec. 4. The Board of Control, with the aid of the Warden of the Indiana Reformatory, shall, between April 1st and April 10th, 1904, select from the able-bodied convicts in said Reformatory, between the ages of twenty-one and thirty, a number not to exceed two hundred, and shall take such convicts under guard to a temporary camp of detention on the site of the future prison. Here, under the supervision of trained men, they shall sink a shaft to the vein of coal, and shall construct temporary kilns and make and burn ordinary brick in sufficient quantity to construct a cell house and other necessary buildings, and to build the walls about a tract of land of sufficient size to surround buildings to be used as factories for the future making and burning of vitrified and other brick. The cell-houses, walls, factories and all other necessary buildings shall be constructed, as far as possible, by convict labor. As soon as the necessary buildings for sheltering and confining the prisoners are completed, factories and kilns shall be erected and equipped with the necessary machinery for the making of vitrified and other brick. The Board of Control shall then bring from the reformatory at Jeffersonville to the new prison, additional convicts, not exceeding three hundred in number, to be selected in the same manner as the first removed. Said Board shall also at discretion, and by and with the consent and aid of the Board of Control of the Indiana State Prison, have power to remove from that Institution to the Industrial Prison, a number not to exceed three hundred of the least vicious, short-term, able-bodied convicts not engaged in contract labor. Judges of criminal courts in the different counties of the State may, at discretion, sentence parties between the ages of twenty-one and fifty, convicted of penal offenses, to the Industrial Prison; but no person shall be sent there whose term of imprisonment is greater than fourteen years; and at no time shall the convicts of said prison exceed eight hundred in number.

Sec. 5. The Board of Control shall make arrangement for buying and

shipping into the prison, rough stone suitable for the making of macadam and concrete material. A portion of the convicts shall be employed in preparing this stone for the foundation and curbing of vitrified brick roads; another portion in making and burning vitrified brick, and a third portion in tilling the soil of the land connected with the prison, the crops so raised to be used in supplying the needs of the institution, and any surplus to be sold to the other State penal institutions. The macadam and vitrified brick prepared and made in the prison shall be sold at actual cost of making, f. o. b. the cars, to the county commissioners of the different counties of the State for use only in the construction and improvement of the public highways of said counties. If at any time the supply of these road materials much exceeds the demand, the Board of Control may, at discretion, employ a portion of the convicts in the making of ordinary building brick, said brick to be sold at cost to the proper officials only for use in the construction of school houses, jails, court houses, poor asylums and other public buildings. The regular hours of a day's work in said institution shall not exceed eight hours, subject to temporary changes under necessity or to fit special cases, to be sanctioned by the Board of Control.

Sec. 6. All officers, guards and employes of said Industrial Prison shall be appointed and selected by the warden of said prison, and by and with the consent of the Board of Control. The Board of Control is hereby authorized to determine the compensation of all the above mentioned employes and warden required in the operating of said Industrial Prison.

Sec. 7. It shall be the duty of the warden to assign the convicts to such work as in his opinion they are particularly fitted for, and to recommend to the Board of Control from time to time such necessary materials, tools, apparatus or accommodations as are needful for the purpose of carrying on and conducting said brick making industry as may be authorized under this act. He shall make a quarterly detailed statement of all materials or other property procured and the cost thereof, and of the expenditures made during the last preceding quarter, together with a statement of all materials then on hand, the amount of all kinds of work in process, the earnings realized during said quarter, and file the same with the Auditor of State.

Sec. 8. The Board of Control of said Industrial Prison shall cause an accurate account to be kept of all receipts and expenditures of said prison and all business transactions thereof, and out of the moneys received from the sale of vitrified or other brick, the product of the labor of the convicts, and also from the sale of farm and garden products as aforesaid, the Board of Control shall have the authority to pay the salaries of the officers, guards and employes of said prison and to pay to each of said convicts in said prison the sum of ten cents (10c) daily. Said convicts' pay to be available monthly should he be a man of family.

Sec. 9. There is hereby appropriated out of moneys not otherwise appropriated the sum of one hundred and fifty thousand dollars (\$150,000), to be used in the purchase of land, tools, machinery, apparatus and accommodations, as may be by said Board of Control deemed necessary for the purpose of conducting said prison and brick plant, the labor of said con-

victs to be employed on the public account system and the sum hereby appropriated shall only be used to establish, provide for and furnish the necessary machinery and materials in the inauguration of such Industrial Prison.

Sec. 10. All laws and parts of laws in conflict with this act are hereby repealed.

Sec. 11. Whereas an emergency exists for the immediate taking effect of this act, the same shall be in force from and after its passage.

THE PETROLEUM INDUSTRY IN INDIANA IN 1904.

BY W. S. BLATCHLEY.

Once more it can be recorded that the Indiana petroleum industry has broken its record. The output for the year 1904 was greater than in any previous year, both in number of barrels produced and in value, though the average market price declined nearly 7 cents. Since 1898 each year has seen an increase in production, and in the seven years the annual output has more than trebled. As a very full report, accompanied by a map, was made on the industry in the State for the year 1903, but brief mention of the more important developments in 1904 will be given in connection with the statistics for the year.

THE TRENTON ROCK OIL FIELDS OF INDIANA FOR THE YEAR 1904.

The new productive territory and the most important developments of the year were mainly in the Muncie-Parker-Selma field of Delaware and Randolph counties, the center of operations having shifted from Marion, Grant County, to Muncie, in Delaware. Here the greater number of wells put down in 1904 were sunk from 280 to 320 feet in Trenton limestone, it having been discovered in the latter part of 1903 that a second or third pay streak occurs in that area at a depth of 240 to 300 feet below the top of Trenton. Heretofore most of the productive wells of the State had been drilled less than 90 feet in the Trenton rock.

In Grant County the new developments were mainly in Washington and Jefferson townships. In Washington, north of Marion, sections 10 and 11, the south halves of 25 and 26 and all of 28, 29 and 33 were added to the fair to good productive area of the map of the previous year. In Jefferson Township, in the south-eastern corner of the county, sections 5, 6, 7, 8, 17, 18, 19 and 20

came in as light productive territory, while bores sunk in 9, 10, 15, 16 and 22 were for the most part dry. Some fair to good territory was opened up in the vicinity of Matthews, in sections 31, 32 and 33 (23 N., 9 E.), and in 1, 2 and 4 (22 N., 9 E.). Bores sunk in sections 22, 27, 28, 32, 33 and 35, Monroe Township, Grant County, were for the most part dry or productive of gas.

No noteworthy extensions of productive territory were made in Huntington County. In Wells quite an area in the immediate vicinity of Poneto was added to the map, section 31, Harrison Township; 34, 35 and 36, Liberty Township; 3 and 6, Nottingham Township, and 1 Chester Township, proving, for the most part, fair territory.

In Blackford County the only new developments of consequence were in sections 6, 7 and 8, Licking Township, where a number of light producers were drilled in.

As noted above, Delaware County furnished the most of the new producing territory. In Washington Township sections 11 and 12 yielded a number of fair wells. In Union Township new productive territory was added to the map along the Mississinewa River, between Eaton and Pittsburg; sections 16, 17, 20 and 22 having yielded a number of fair producers, while some good wells were completed on the north half of 14, one mile north of Eaton.

Quite an area of fair to good territory was opened up in Niles Township, in the northeastern part of Delaware County; sections 19, 20, 21, 22, 28, 29 and 30, in the southwestern corner of the township, producing a number of good wells, while sections 31 and 32 and the west half of 33 were lighter.

Section 1, just east of Shideler, in Hamilton Township, yielded a few light wells. Of two deep bores sunk in wildcat territory on the J. G. Leffer farm, in section 22, Hamilton Township, the first came in dry, while the second started at 60 barrels per day. The records of the two showed as follows:

	No. 1. Feet.	No. 2. Feet.
Drive pipe	57	37
Casing	346	343
Top of Trenton.....	960	914
Total depth	1,396	1,238

A bore sunk by the American Sheet Steel Company just north of Bethel, in Harrison Township, was through Trenton limestone, its thickness being found 800 feet.

In Delaware Township the main developments of the year were in sections 8, 9, 16 and 17, three or four miles east of Albany. Of three deep bores sunk on the J. G. Beck farm, section 16, No. 1 was dry, while Nos. 2 and 3 started 200 barrels, respectively. A record of the bores was

	<i>No. 1.</i> <i>Feet.</i>	<i>No. 2.</i> <i>Feet.</i>
Drive pipe	80	80
Casing	380	370
Top of Trenton	940	960
Total depth	1,280	1,290

In Center Township, Delaware County, the only well opened up was west of White River and just southeast of sections 14 and 15, where the wells drilled were getting some output. Two bores on the J. C. Quick farm, in sections 14 and 15, of which yielded salt water and the other 25 barrels, following records:

	<i>No. 1.</i> <i>Feet.</i>
Drive pipe	104
Casing	348
Top of Trenton	898
Total depth	1,212

Liberty Township, in which the towns of Selma and Smithfield are located, was, in 1904, the seat of the greatest activity in the entire Indiana field. By the close of the year the entire township, with the exception of sections 2 and 12, in the northeast corner, and the west half of section 18, was producing more or less oil. The most of the area could be classed as good, the lighter sections being 6, 7, 13, 24 and 25.

The scene of most excitement during the year was at Smithfield, where, at one time, in May, 37 derrick wells were to be seen on an area of not more than 40 acres. At first the first wells in the town came in as big producers, but as the pool had been pumped down until only small wells remained. In October the main work was being done near Mt. F.

etery, in section 36, Delaware Township, where a new pool of much promise had been opened.

In general the oil in the deep pay wells in Liberty Township is found between 270 and 300 feet in Trenton. An occasional bore is sunk as low as 350 feet in, but they are poor producers. Sometimes what is known as a "stray pay" is found at 150 to 200 feet. The bores in which they occur make quite a showing for a few days, but soon drop to little or nothing. The average deep pay well holds up better than the more shallow ones, a 250-barrel one yielding about 75 barrels at the end of six months. But little gas is now developed in the bores sunk in the township. In October there was barely enough to utilize gas engines for pumping, and for such purpose gas was selling at 60 cents per thousand cubic feet. Drilling was being done with Hocking Valley coal, costing \$3.00 per ton.

The oil from the deep pay wells is a little heavier than that from the more shallow ones, and has a tendency to hold together with water, so that most tanks have to be steamed. It is a higher grade product than any other Indiana oil, but the Standard does not recognize that fact, and pays the same per barrel as for South Lima. The average deep pay well is shot with 160 quarts of nitroglycerine. The "sand" or pay streak usually runs from eight to ten feet in thickness, but in some of the best wells occurs 30 to 50 feet thick.

On account of greater depth and increase in cost of lumber and iron, the cost of a well in the deep pay region about Selma ran about \$600 more in 1904 than in the shallow bores of the same region in 1903. A careful estimate of the cost of drilling and fitting up the first productive deep pay well on a lease in the Selma field in October, 1904, ran about as follows:

Rig or derrick.....	\$425
Drilling	900
Drive pipe	120
Casing	120
Shooting	140
Tubing and pumping outfit.....	220
Power house and power.....	725
Two tanks	180
Belting and lead lines.....	125
Incidentals	100
Total	<u>\$3,000</u>

After the power was in place, each succeeding well could be added for about \$1,700, and, without shooting, each dry hole cost \$1,000. The price of drilling was 50 cents a foot to the bottom of the first 50 feet in Trenton, \$1.00 a foot for the next 100 feet and \$1.50 for the remainder. Twenty-five cents extra per foot was charged for all drive pipe above 100 feet. The rig was erected by the operator and the contractor furnished his own fuel. Most drilling was being done by contract, though a few of the larger companies were operating their own strings of tools. In general the Standard rig was used, but a few Star machines were at work. Drillers were receiving \$4.50 and tool dressers \$3.50 per shift of 12 hours, while pumpers were getting \$50 a month.

One of the best areas operated in southwestern Liberty Township in October was in sections 20 and 29, on the farms of Collins and Cecil. On the Collins lease of 140 acres there were six wells yielding 125 barrels each and one dry hole within 600 feet of one of the best wells. On the Edward Cecil lease there were four and on the Walter Cecil nine wells, the thirteen averaging 75 barrels each. A record of No. 1 Walter Cecil and No. 2 Collins ran as follows:

	No. 1 Cecil.	No. 2 Collins.
	<i>Feet.</i>	<i>Feet.</i>
Drive pipe	123	207
Casing	328	320
Top of Trenton.....	927	913
Total depth	1,197	1,190

The No. 1 Cecil was what is termed a crevice well, coming in on July 27 as a 200-barrel producer without being shot. The No. 2 Collins started September 30 at 200 barrels and was producing 100 barrels daily on October 27. No top or shallow pay was found in either well. On the Louis Reese lease a bore 80 rods south of the Cecil No. 1 developed top pay at 30 feet in Trenton. This was about five feet thick, and was good for eight to ten barrels daily. The bore was continued to 275 feet in Trenton and started off at 150 barrels. Before being operated an annual rental of \$1.00 an acre had been paid for this area for ten or more years.

A few light wells and several dry holes were sunk in the north half of Perry Township, just south of Liberty, during the year.

On the Z. T. Dunkin lease of 100 acres, in the northwest quarter of 28, Liberty, there were 19 producing wells on October 27.

Of these 15 were deep pay wells, drilled between March and October. Three of them started at over 100 barrels and the 19 were making a total of 350 barrels on the date mentioned. Two of the wells, Nos. 8 and 10, had the following records:

	No. 8. Feet.	No. 10. Feet.
Drive pipe	94	96
Casing	345	345
Top of Trenton.....	951	946
Total depth	1,229	1,231

No upper pay was found in either. No. 8 started at 25 barrels and No. 10, on July 10, at 125 barrels. On October 27th it was yielding 25 barrels per day. Dunkin was receiving \$50 a day royalty from the 100 acres, and had received altogether about \$10,000.

On the Arthur Cecil lease of 200 acres, just north of Dunkin, in section 21, there were 22 wells producing, 16 of which were in deep pay. The average bore on this lease found Trenton at 932 feet and the lower pay at about 1,210 feet. Water was usually found in the upper porous stratum where oil was formerly looked for, but not in sufficient quantity to cause trouble. The lower pay averaged about 11 feet in thickness.

On the H. K. Lewis farm, just north of Smithfield, the sound of the pumping gas engine was heard on every side. Twenty-one wells were producing, eighteen of which were in deep pay. Only one dry hole had been bored, and the best well started at 320 barrels. Three others had an initial output of 300 barrels each. A record of the No. 8 bore, which started June 25 at 300 barrels, may be taken as an average of the lease, and showed as follows:

	Feet.
Drive pipe	103
Casing	340
Top of Trenton.....	922
Total depth	1,208

When finished this bore and the seven preceding made 850 barrels a day for some time. The new wells since put down had not kept the production up to that figure, i. e., the production fell off faster than the new wells could add to it, and on October 27 the 21 producing wells were yielding a total of 600 barrels per day.

The Utica shale, which overlies the Trenton, is in the vicinity of Smithfield, about 200 feet thick and light brown in color. The Hudson River shales and limestones run more uniform in color and texture than in the main field. About Marion they are said to vary from light to dark blue every 25 or 30 feet.

The latest and one of the best so-called pools opened up in Liberty Township in 1904 was in the northeast corner, in the northeast quarter of section 11, the southeast of 2 and the northwest of 1. The pool also includes the southwest quarter of 36, Delaware Township. The Commonwealth Jewel and Oil Company were operating 20 wells in the southwest of 36 and northwest of 1, which were making 1,200 barrels per day the last of October, and had produced as high as 1,500 barrels. The James Baughn No. 1, in the southwest of 36, finished July 13, was the biggest producer in the State for the year. It is said to have started at 800 barrels and filled 40 250-barrel tanks the first two weeks. On October 27 it was yielding about 50 barrels per day. The record of the bore showed as follows:

	<i>Fect.</i>
Drive pipe	27
Casing	325
Top of Trenton.....	921
First oil	1,181
Total depth	1,213

From the time the first oil was struck, at 1,181 to the bottom, a distance of 32 feet, the drill passed through a very porous brown limestone or pay streak. No shallow or top pay occurs in this part of the township.

From the office of the Commonwealth Jewel Company, on the middle of the south line of section 36 (northeast corner of Liberty Township), or near Mt. Pleasant cemetery, 75 derricks could be counted on October 27, all of which had been erected since June 17, when the first well in the pool came in on the M. S. Thorpe lease. Most of the drilling has, for some reason, been done on the lowlands along the streams, though there is no reason for the belief that such locations will furnish the better wells. Much untested territory, which will eventually prove productive, lies west and southwest of the Mt. Pleasant pool.

In Randolph County the main developments of the year were

in Monroe and Stony Creek townships. North of the famous Cecil pool, near Parker, a number of good wells were drilled in on section 34 (21 N., 11 E.) and on 3, 4 and 5 (20 N., 11 E.). Section 28, Stony Creek Township, has also become good territory, while the area between it and Parker is all productive.

The importance of the developments in the Muncie-Parker-Selma field is best shown by the following table of production by months for the year, the output for October being nine times as great as for January:

NUMBER OF BARRELS OF OIL PIPED OR SHIPPED FROM THE MUNCIE-PARKER-SELMA OIL FIELD IN 1904, BY MONTHS.

January	42,835
February	33,081
March	40,869
April	46,504
May	73,162
June	115,048
July	176,624
August	240,050
September	311,098
October	384,380
November	356,173
December	382,302
Total	2,202,126

The most important developments of the year 1904 in Jay County were in sections 12, 13, 14, 16, 17, 20, 21, 23, 24, 26, 27, 31, 32, 33 and 36, Bear Creek Township; in sections 10, 13, 24 and 28, Richland Township; sections 5, 8, 17 and 32, Wabash Township, and sections 3, 4 and 17, Noble Township.

In Bear Creek Township the developments of greatest importance were in sections 16, 17, 20, 21 and 33, in what was formerly considered worthless territory, having been condemned by numerous dry holes, that were drilled several years ago. This area now furnishes wells that have an initial production of from 25 to 100 barrels.

The developments in Richland Township were in the deep pay. The oil was found at different depths in Trenton, varying from 85 to 415 feet. On two farms adjoining are wells in which the oil pay is found at five different depths in the sand; that is, each well

yields its oil from a different horizon from that of its neighboring well. One well yields from the top or shallow pay, 15 to 20 feet in Trenton. A second well, only 400 feet distant, is producing from 300 feet in Trenton. A third an equal distance from the second, gets its oil from 80-foot pay, a fourth from 156-foot pay, and a fifth from 415-foot pay. The deeper pay wells were the most prolific producers in the start, some of them yielding from 200 to 450 barrels.

In Wabash Township some especially good wells were finished in section 17 and four fair ones in section 32. In Noble Township two wells were completed during the latter part of the year in section 17 which opened up a large area of new territory that promises to be of considerable importance.

In section 19, Greene Township, a pair of fair producers were also completed late in the year. In them the oil pay was found at a depth of 85 feet in Trenton, the initial production being 25 to 40 barrels.

Two small wells were also drilled in sections 15 and 23, Madison Township. While the initial output was small, the showing was sufficient to warrant further drilling in that vicinity. These wells, together with a showing of oil at or near Saratoga, Randolph County, indicate the possibility of an extension of the field from Wabash Township, Jay County, southward into Randolph County.

In Adams County the new developments were in sections 32 and 36, Wabash Township and sections 27, 28, 33 and 34, Jefferson Township. The wells drilled in sections 28 and 34, Jefferson Township were large producers, and indicate that a new area may become productive in that vicinity.

In most of the isolated areas producing Trenton limestone petroleum in the State the production gradually fell off, and was less in October, which is considered the best month in the year, than in January.

In the Alexandria field 46 bores were sunk, 14 of which were dry, while the average initial output of the productive wells was but 11 barrels. The production by months follows:

**NUMBER OF BARRELS OF OIL PIPED FROM THE ALEXANDRIA,
INDIANA, FIELD IN 1904, BY MONTHS.**

January	19,705
February	19,537
March	20,745
April	21,639
May	23,646
June	29,207
July	28,666
August	28,012
September	6,834
October	6,071
November	7,128
December	5,446
Total	<hr/> 216,636

In the Peru-Rich Valley field nine bores were sunk during the year, four of which were barren. The five productive ones had an average initial output of $6\frac{1}{2}$ barrels each. The production of this pool for the year was but 54,540 barrels, distributed among the months as follows:

**NUMBER OF BARRELS OF OIL PIPED FROM PERU AND RICH
VALLEY, INDIANA, OIL FIELDS IN 1904, BY MONTHS.**

January	4,554
February	2,907
March	3,903
April	4,550
May	4,061
June	5,453
July	4,968
August	5,675
September	5,374
October	4,478
November	5,241
December	3,356
Total	<hr/> 54,540

No new wells were drilled in the Broad Ripple (Marion County) field and the production dwindled from 8,126 barrels in 1903 to 4,558 barrels, distributed among the months as follows:

NUMBER OF BARRELS OF OIL PRODUCED FROM PRO-
INDIANA, FIELD IN 1904, BY MONTHS.

January
February
March
April
May
June
July
August
September
October
November
December
Total

STATISTICS OF THE INDIANA TRENTON
TROLEUM INDUSTRY FOR 1904.

As already mentioned, the output of petroleum from the limestone fields of Indiana was greater in 1904 than in the previous year. This was due largely to the discovery of "deep pay" in Delaware County and the consequent drilling of hundreds of new wells in that section. A second and increased production was the fair average price received throughout the year. New wells were constantly coming in and old ones were pumped to their full capacity. When the oil falls below 80 cents the operator often becomes discouraged and stops drilling. Producing wells are also often abandoned. When the price ranges from 80 cents to \$1.00 the operator is making a good profit, and the amount of production, if the field has not reached its limit, is always advanced.

While the tendency in price during nearly the entire year was downward, it at no time fell below 95 cents. Starting at the maximum price of \$1.31, it held that figure until January 12, when it dropped to \$1.26. This price was paid until January 1st, when it began slowly to decline, and on July 1st reached a minimum of 95 cents. This was maintained until August when it rose to 98 cents. On September 25 it hit the dollar mark and on November 11 advanced to \$1.05.

was paid until December 17, when another decline began, the price at the close of the year being 96 cents. The average price for the year, taking both time and amount received into consideration, was \$1.07 $\frac{1}{2}$, as against \$1.14 $\frac{3}{10}$ in 1903.

The total production of Trenton rock oil in Indiana in 1904 was 11,281,030 barrels, which, at the average price of \$1.07 $\frac{1}{2}$, brought into the State \$12,127,107. Compared with 1903, this was a gain of 2,119,699 barrels, or 21.3 per cent., as against a gain of 21.6 per cent. in 1903. However, on account of the lower average price, the amount received by the producers was but \$1,669,448, or 15.9 per cent., more than in 1903.

The first of the following tables gives a complete record of the monthly production of petroleum from the Trenton limestone fields of Indiana for the 14 years beginning January 1, 1891, and ending December 31, 1904. This does not include the amount used in the field for fuel and other purposes, or that wasted by the burning of tanks or the leaking of pipes, but only that shipped or piped by the companies who purchase the oil from the operators. The second table shows the annual production, the average yearly price and the total value by years for the same period.

I. TOTAL PRODUCTION OF TRENTON LIMESTONE PETROLEUM IN INDIANA FROM 1891 TO 1905, BY MONTHS.

MONTH.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	1903.	1904.
January.....	6,171	15,841	111,824	259,000	300,568	365,552	290,746	317,014	297,291	353,451	425,140	554,088	651,355	714,694
February.....	5,981	18,946	98,025	232,107	230,559	281,745	309,922	272,780	220,440	302,453	364,735	460,073	568,789	661,058
March.....	6,159	24,794	134,549	262,876	310,393	390,566	391,961	325,301	220,557	304,589	432,922	573,411	724,969	797,133
April.....	6,787	26,154	146,493	297,530	352,077	386,032	328,779	310,034	325,774	331,804	447,261	579,711	690,391	804,121
May.....	5,767	31,053	186,939	321,502	357,001	417,963	340,023	311,208	344,331	426,363	482,118	685,752	751,348	851,071
June.....	8,136	40,888	209,616	339,749	403,569	434,167	369,303	320,477	324,292	416,492	481,807	633,452	809,438	940,391
July.....	10,809	49,203	221,666	337,349	434,576	422,968	375,249	314,861	329,065	437,087	506,065	696,911	831,006	998,239
August.....	11,603	56,109	248,353	345,031	420,133	407,228	371,921	332,777	347,521	466,127	523,106	697,040	838,615	1,084,560
September....	16,500	66,034	245,615	319,588	409,169	415,675	362,628	326,264	332,785	418,716	519,087	677,811	867,117	1,104,771
October.....	19,029	95,699	252,568	389,424	583,153	391,283	408,179	319,490	326,781	452,973	532,940	725,973	873,160	1,139,000
November....	20,801	129,270	245,607	304,030	973,789	337,331	430,968	300,644	338,892	406,694	510,788	656,467	778,823	1,098,532
December....	21,715	144,097	236,038	337,450	361,456	362,164	433,099	300,457	332,266	441,347	479,485	650,131	796,291	1,084,270
Totals.....	136,634	698,068	2,385,293	3,698,466	4,386,132	4,980,732	4,353,138	3,751,307	3,807,714	4,912,676	5,725,474	7,535,661	9,161,331	11,281,030

III. PRODUCTION OF TRENTON ROCK PETROLEUM IN INDIANA FROM 1891 TO 1905, WITH VALUE.

[illegible]

From the first of the above tables it will be seen that the largest production of Trenton rock petroleum in Indiana in any one month was in October, 1904, when 1,139,000 barrels were brought to the surface. The total production of Indiana Trenton rock oil for the 14 years reached the enormous sum of 66,453,785 barrels, which sold for \$54,884,941, or an average of \$3,920,353 per year.

In the third table there is shown the number of wells completed in Indiana by months from June, 1891, to January, 1905:

III. NUMBER OF WELLS COMPLETED IN THE INDIANA TRENTON LIMESTONE OIL FIELDS FROM 1891 TO 1905, BY MONTHS.

YEAR.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1891.....							6	6	15	15	15	8	65
1892.....	11	13	18	13	17	19	17	30	25	52	33	47	295
1893.....	20	30	31	36	45	47	47	55	27	72	56	76	542
1894.....	90	103	103	80	110	107	84	123	100	107	97	85	1,189
1895.....	61	45	81	111	122	153	132	140	129	106	102	85	1,267
1896.....	76	90	86	136	148	150	113	121	70	58	66	66	1,180
1897.....	41	35	40	47	49	52	60	45	55	89	119	54	686
1898.....	41	23	29	43	38	55	53	80	72	82	92	86	694
1899.....	75	48	68	64	87	99	77	104	106	118	106	105	1,057
1900.....	118	67	98	148	165	163	158	185	135	152	118	108	1,580
1901.....	111	72	81	121	167	171	167	169	184	207	220	132	1,802
1902.....	176	113	169	182	247	297	268	279	328	265	320	243	2,932
1903.....	168	178	233	236	331	408	377	387	337	366	375	290	3,686
1904.....	235	157	234	202	296	393	394	383	378	388	320	344	3,724
Total ..													20,699

From this table we learn that but 38 more bores were sunk for oil in the Trenton rock fields of Indiana in 1904 than in the previous year. In 1903 the gain over 1902 was 754. Outside of Delaware and Randolph counties, the great majority of new bores were sunk in already proven territory by companies whose members were content to sink fair producing wells and develop what oil they could beneath their leases rather than seek far and wide for new territory which might produce a "gusher."

From the table it may also be learned that up to January 1, 1905, 20,699 bores had been drilled in the Trenton rock fields of

Indiana for oil alone. On that date there were 15,228 producing wells in the fields, as against 12,098 on January 1, 1904, a gain of 3,130 for the year. By subtraction it will be noted that of the total number of bores sunk for oil in the Trenton rock fields of the State 5,471 have proven dry, or have been abandoned as non-productive. The number abandoned in 1904 was 211, or 36 more than in 1903, while the number of dry holes drilled during the year was 383, or seven more than in 1903. Of the total number of bores sunk in 1904, 10.2 per cent. were dry, this percentage being exactly the same as in 1903.

On October 15, 1904, there were approximately 14,440 producing wells in the Trenton rock fields of the State. The production of oil for the entire month of October was 1,139,000 barrels, or an average of 2.54 barrels per well for each day of the month. The average daily output in October, 1903, was 2.48 barrels for each productive well. This shows a slight gain for the year, due to the larger production of the deep pay wells in the Selma-Parker field.

Since the average output per well is always less during the winter months than during other seasons, the average for the year would probably be about 2.4 barrels per well per day, a seemingly small amount, yet totaling more than 11,250,000 barrels for the field for the year 1904.

These figures go to prove that the days of the gusher are practically over in the older portions of the main field, where most of the bores were sunk. It is better for the practical producer that this is true. A well starting at 200 barrels or more a day creates an excitement and a rush for territory that, in the end, proves harmful to all concerned. Large bonuses are paid out and big risks taken which are foreign to territory whose wells are small but sure producers. As has been stated in my former reports, one large well will not make any man a fortune; twenty small ones may in time. The yield of the large producer will quickly grow much less; that of the twenty small ones will hold out for a long time. There is yet room for thousands of wells in the known productive territory. At present prices, eight to ten wells, pumped by one power and yielding on an average but one and a half barrels each per day, will prove a paying investment.

The following table shows the number of producing wells, number of dry holes, total bores and average initial production of wells drilled in each of the Trenton rock oil producing counties of Indiana in 1903 and 1904:

COUNTY.	Producing Wells, 1903.	Producing Wells, 1904.	Dry Holes, ^a 1903.	Dry Holes, ^a 1904.	Total bores, ^c 1903.	Total bores, ^c 1904.	Percentage of Dry Holes, 1903.	Percentage of Dry Holes, 1904.	Average Initial Production of Productive Wells, 1903.	Average Initial Production of Productive Wells, 1904.
Adams.....	287	237	30	25	317	262	9.4	9.5	15.1	13.1
Allen.....	2	0	2	0	4	0	50.	0	25.	0
Blackford.....	353	201	31	21	394	222	10.4	9.4	11.1	9.8
Delaware.....	74	831	48	121	122	952	39.3	12.7	20.7	44.4
Grant.....	1,289	977	94	91	1,383	1,068	6.8	8.5	15.1	11.2
Hamilton.....	0	0	7	0	7	0	100.	0	0	0
Huntington.....	302	324	10	8	312	332	3.2	2.4	19.4	18.2
Jay.....	180	277	33	52	213	329	15.5	15.8	13.4	17.1
Madison.....	46	35	19	15	65	50	29.2	30.	8.	10.5
Miami.....	1	5	1	3	2	8	50.	37.5	5.	6.4
Randolph.....	78	86	50	27	128	113	39.	23.9	43.	43.2
Wabash.....	3	0	1	1	4	25.	100.	3.	0	0
Wells.....	695	368	40	19	735	387	5.4	4.9	14.	12.
Totals.....	3,310	3,341	376	383	3,686	3,724	†10.2	†10.2	†14.2	†18.6

*These columns include bores sunk for oil which yielded gas.

†Denotes average.

From the table it will be seen that the average initial production for the year in the entire field gained 4.4 barrels, being 18.6 barrels per well, as against 14.2 barrels in 1903. This gain was due almost wholly to the high initial output of the deep pay wells of Delaware and Randolph counties, all the older producing counties, except Jay, falling off in initial production. In Delaware the average jumped from 20.7 to 44.4 barrels, while in Randolph there was but a slight gain, as most of the productive bores sunk in that county in 1903 were heavy producers at the start. In Jay County there was a gain of 3.7 barrels per well.

The table gives only a partial idea of the importance of the deep pay developments in Delaware County. The number of productive bores in the county increased from 74 to 831, while the percentage of dry holes dropped from 39.3 to 12.7 per cent. Of the 72,152 barrels increase in new production in the entire field during the year, Delaware County alone furnished 36,877 barrels, or more than 50 per cent.

Grant County outranks Delaware in the number of bores sunk during the year and in the lower percentage of dry holes, but the

wells being mostly in shallow pay, showed only about one-fourth the average initial production of those of Delaware. Huntington again leads all the older producing counties, with an average initial output of 18.2 barrels, while its percentage of dry holes was but 2.4. A bore sunk within known productive limits in Huntington County is almost as sure a venture as one can make anywhere in the United States in the oil business. Wells County dropped to third place in the number of bores sunk, but at the same time decreased its percentage of dry holes from 5.4 to 4.9, ranking next to Huntington in low percentage. From a careful study of the table one can learn many other facts regarding the relative importance of each county in the field.

CORNIFEROUS ROCK PETROLEUM.

No new territory producing Corniferous rock petroleum was opened up in Indiana in 1904. The two wells at Terre Haute still continue to produce, but the output is slowly decreasing, having fallen from 13,940 barrels in 1903 to 8,303 barrels in 1904. The greater part of this was sold to local consumers at an average price of \$1.25 per barrel, the whole amount received being \$10,260.

In the Jasper County field 9,800 barrels of heavy Corniferous petroleum were produced during the year. This, at the average price of \$1.10 per barrel, brought \$10,780. In September the Indian Asphalt Company ceased to purchase it at their refinery at Asphaltum, Jasper County. Richmond Levering, president of the company, kindly furnished me the following information regarding the physical and chemical properties of the Jasper County product. The figures "were taken from actual runs made at the refinery upon a large scale."

"Distillation started at 248° F. Thirty-eight gravity oil, light yellow in color. The total amount of distillates obtained when running the crude down to asphalt were 49 per cent, the loss was 4 per cent. and the amount of asphalt 47 per cent.

<i>Average gravity.</i>	<i>Flash.</i>	<i>Fire.</i>	<i>Viscosity.</i>
26.2	272°	302°	170
25.4	292°	335°	210
24.8	312°	348°	310
24.0	338°	374°	728

"The viscosity of the crude at 90° Fahr. is 1274; gravity, 19.40 B.; at zero the crude will not flow through the viscosimeter, although its chill point cannot be obtained accurately, as there is no paraffine in it."

HURON SANDSTONE PETROLEUM.

Petroleum from the Huron sandstone is now produced in Indiana only in the vicinity of Princeton, Gibson County. A number of wells producing oil from this formation were pumped from 1900 to 1903 near Loogootee, Martin County, but all have been abandoned, the output for 1904 having been but 198 barrels, valued at \$218.

In the Princeton field, on January 1, 1905, there were 45 wells producing oil, eight yielding gas and 13 dry holes. Some of the latter would probably yield one or two barrels each per day if pumped. During the year 50 bores were sunk. Of these the majority were small producers, having an initial output of about five barrels. The top of the oil-bearing stratum, which is a bluish gray, sharp-grained sandstone, is found at an average depth of 890 feet below the surface. The oil is found at about 40 feet below the top of this "sand." It is darker and thicker than that found in Trenton limestone, registering about 31° Beaumé. For a long time the Indiana Pipe Line Company paid 35 cents less per barrel for it than for the Trenton limestone product, but on August 15th advanced the price to the same figure.

The Princeton field for the year 1904 produced 32,207 barrels, distributed among the months as follows:

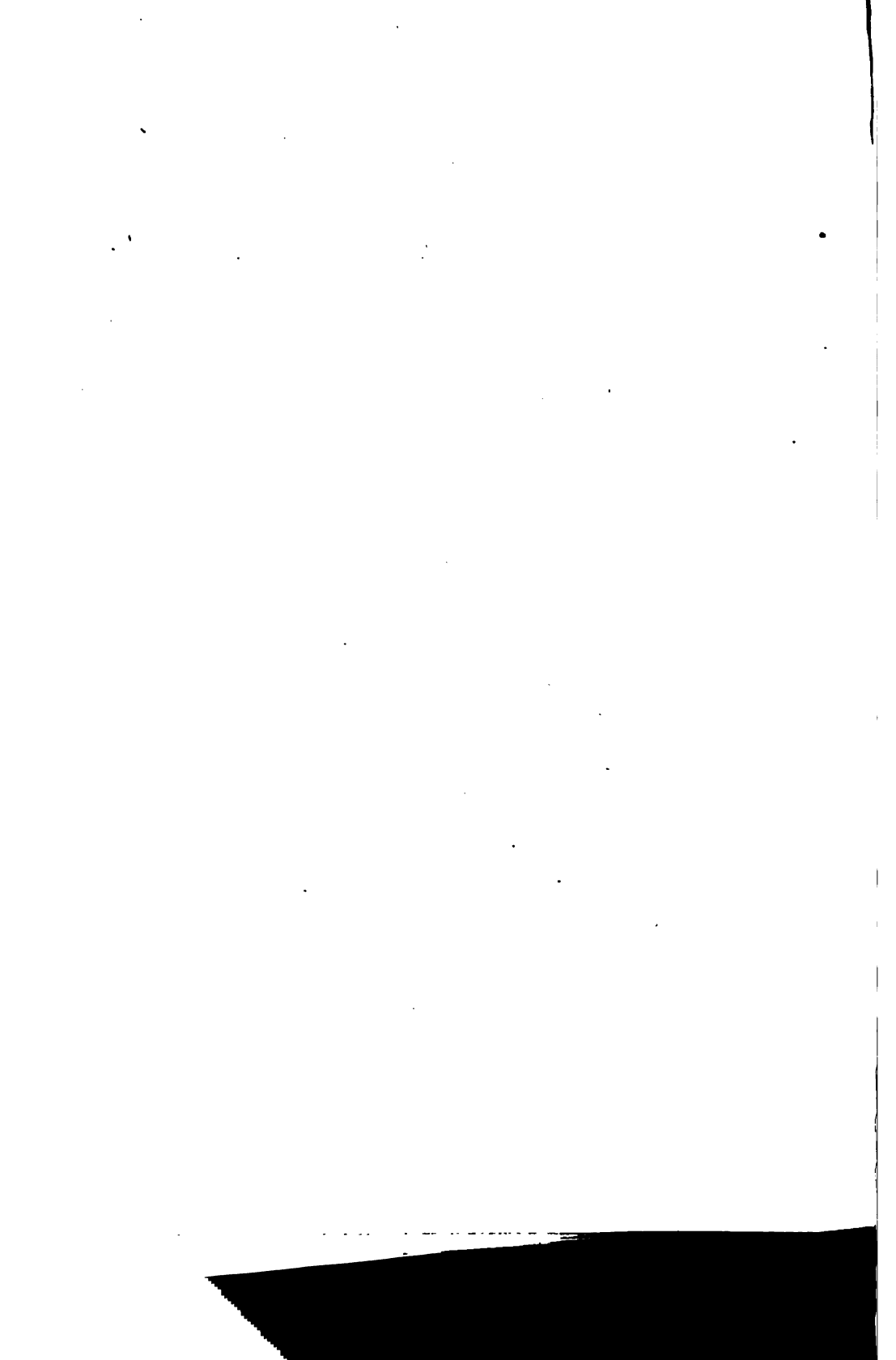
NUMBER OF BARRELS OF OIL PIPED OR SHIPPED FROM PRINCETON, INDIANA, FIELD IN 1904, BY MONTHS.

January	1,412
February	1,399
March	2,920
April	1,319
May	2,047
June	2,315
July	2,971
August	2,991
September	3,345
October	3,093
November	4,554
December	3,841
Total	32,207

The output of the Princeton field for the year sold for \$28,733, or an average of 89.2 cents per barrel.

Adding to the output of the Trenton rock petroleum fields that produced by the Corniferous limestone at Terre Haute and in the Jasper County field, and by the Huron sandstone at Loogootee and Princeton, we find the total production and value of petroleum in Indiana in 1904 to be as follows:

	<i>Barrels.</i>	<i>Value.</i>
Trenton Rock Oil.....	11,281,030	\$12,127,107
Corniferous Rock Oil.....	18,103	21,040
Huron Rock Oil.....	32,207	28,733
Total	11,331,340	\$12,176,880



INSECT GALLS OF INDIANA.

MELVILLE THURSTON COOK, PH. D.

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Some years ago I became interested in the study of gall insects and the structures produced by them. Having recently moved from the State I present this brief review of the subject, hoping that some one will be sufficiently interested to continue the work. I have also collected in the neighboring States of Illinois and Ohio, and from these States have a number of galls which I have not collected in Indiana, but which doubtless occur in the State.

Not only have a number of known species been overlooked, but there are also a great many undescribed species which will demand the attention of the student. The morphology and physiology is still an open field, but probably the most interesting field will be the rearing and studying the life history of these insects in the light of that masterly work by Dr. Hermann Adler on Alternating Generations.*

However, the student who takes up this work must expect to meet with a great many difficulties. It will be necessary to make careful observations and experiments through several seasons, and the problem will be very much complicated by the presence of numerous parasites and inquilines which in many cases belong to the same families as the gall makers.

Abnormal growths on plants may result from any one of several causes; a severe mechanical injury, a repeated mechanical injury or a chemical stimulus due to the action of some insect, a fungous growth, the combined action of insect and fungus, character of soil or fertilizer, or from unknown causes. We wish at this time to speak especially of these structures produced on plants by insects.

*Adler—"Ueber den Generations—wechsel der Eichen Gallwespen." Translation, "Alternating Generations, a Biological Study of Oak Galls and Gall Flies," by Charles R. Straton.

These abnormal growths have attracted the attention of the earliest writers. Redi,* like all other vitalists of his time, believed in a soul in each plant and that this soul controlled the formation of the egg, the gall, and the insect and determined their specific character.

Malpighi, a physician to Innocent XII, professor of medicine at Bologna, and later at Messina, was the earliest systematic writer on galls. In 1686 he published his "De Gallis," which gave very accurate descriptions of the galls then known to Italy and Sicily. He believed that in the case of the *Cynips* at least the insect secreted a poison which excited a fermentation in the acid and this resulted in the formation of the gall.

Among the modern European writers Hartig, Ratzeburg, Lacaze-Duthiers, Giraud, Schenck, Reinhard, Taschenburg, Schlechtendal, Wachtl, Förster, Lichtenstein, Adler, Kieffer, Rubsaamen, Beyerinck, Straton, Nalepa, Mayr, Cameron and Rothera have added to our knowledge of these growths.

In America the pioneers in this subject were Baron C. R. Osten-Sacken, Bassett, Walsh, Riley, Fitch, Shimer and Harris, who have done most of the work. Among the modern workers who have written on this subject are Ashmead, Beutenmüller, Pergande, Cockerell, Garman and Gillette.

Nearly all plants are subject to gall formations which are incited by insects representing six entirely different orders as follows: Arachnida (*Eriophyidæ* or *Phytoptidæ*), Hemiptera (*Aphididæ*, *Psyllidæ* and *Coccidæ*†), Diptera (*Cecidomyidæ* and *Trypetidæ*), Coleoptera (*Bupestidæ*), Lepidoptera (*Gelechidæ*), and Hymenoptera (*Cynipidæ* and *Tenthredinidæ*).

* Born A. D. 1626.

† Up to the present time coccid galls have been reported only from Australia by W. W. Froggatt and C. Faller.

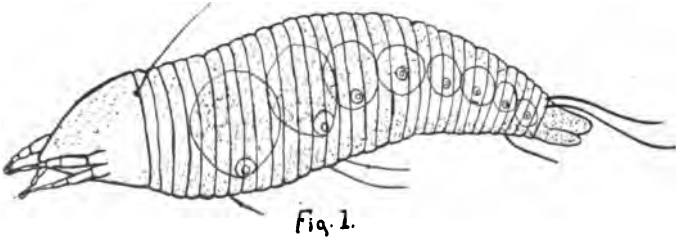
The writer has recently found a coccid gall producer on the Anones and figs in Cuba.

BIOLOGY OF GALL PRODUCING INSECTS.

ORDER—ARACHNIDA.

FAMILY—ERIOPHYIDÆ (PHYTOPTIDÆ).

All the members of this family are plant feeders and many of them produce galls. The adult mite has four legs near the anterior part of the body, the two posterior pairs being lacking (Fig. 1). The early students of the mite galls were unable to see the mites and therefore supposed the galls to be fungi. The mites pass the winter within the buds or possibly under the bark. With the coming of spring they attack the young leaves and produce their characteristic galls and deposit their eggs. The new generation spreads over the plant and produces new galls upon the young



leaves and thus one generation follows another until the approach of winter makes it necessary for the adults to hibernate.

Certain species are very injurious to our cultivated plants. Among the most important is *Eriophyes pyri* Schenten, the pear leaf blister mite, which was introduced from Europe previous to 1870. Like many other introduced insects they are more injurious in this country than in their original home. It is widely distributed throughout the pear growing regions and probably exists in Indiana, although I have not collected it here.* The mites pass the winter in the buds and in the spring attack the young leaves, forming red blister-like galls about one-fourth inch across, which become green and then turn brown.

* Prof. Slingerland in a Bulletin of the Cornell Experiment Station reports that it can be destroyed by the using a 5 to 7 per cent. kerosene emulsion applied with a spray early in the spring before the leaves appear. Aldrich in Bulletin No. 26 of the Idaho Agricultural Experiment Station reports that in Idaho it is necessary to use a 20 per cent. kerosene emulsion.

Eriophyes oleivorus Ashmead, attacks the oranges and lemons in California and Florida. It causes the leaves to curl, the orange fruit to become brown and the lemon fruit to become silvery. The oranges thus affected are said to ship better than unaffected fruit and although not so pleasing to the eye are said to be more juicy. They are frequently sold on the market under the name of russet oranges.

Another European Species is *Eriophyes phloeoptes* Nalepa (*Cecidoptes pruni* Amerling), which produces small subspherical galls at the base of the buds of plum trees.

ORDER—HEMIPTERA.

Two families of this order, *Aphididæ* and *Psyllidæ* produce galls which range in complexity from a simple leaf curl to a very high degree of complexity.

FAMILY—APHIDIDÆ.

This is the family of the plant lice (Fig. 2) which includes a number of gall makers. They are small, soft bodied insects which suck the juices of plants through a tubular mouth. There are a

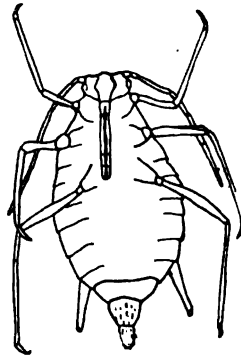


Fig. 2.

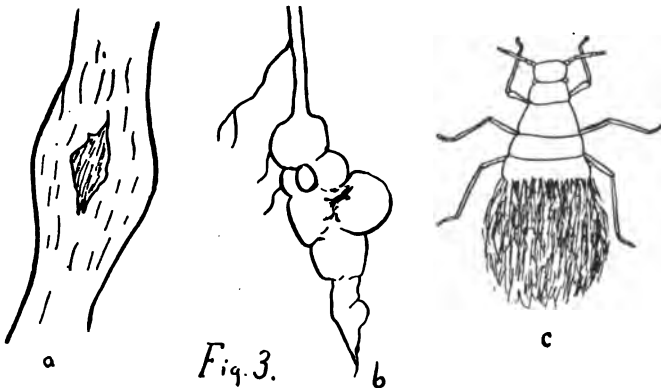
large number of species, and practically all kinds of vegetation are subject to their attacks.

The various species differ widely in their development and the following is intended merely for a general description. The first spring brood usually comes from winter eggs and is known as the

wingless agamic brood. This brood reproduces rapidly without males, but from time to time winged agamic individuals appear and fly to new plants and form new colonies. With the approach of winter a sexual generation is produced in which the males may or may not have wings but the females are always wingless. These females are impregnated and lay the winter eggs which produce the wingless agamic spring brood.

Among the most injurious is the grape Phylloxera, *Phylloxera vastatrix* Planchon (Figs. 46, 47). It is a native of the United States east of the Rocky Mountains, where it seldom does much damage. It was introduced into France previous to 1863 upon vines from America. In its new home it was soon recognized as a serious pest and in 1884 about 2,500,000 acres, or more than one-third of the vineyards of France, were affected, which resulted in great loss. It was afterwards introduced into California, probably on vines from France, and also possibly from the eastern United States, and has proved a serious pest. It has four well recognized stages: (1) the sexual form, consisting of a single fall generation; (2) the leaf gall stage, consisting of from one to five generations; (3) the root gall stage, consisting of several generations; (4) the winged form, which is a single summer generation. The leaf gall form may be omitted.

Schizoneura lanigera Hansen, attacks the apples, producing scars on the branches (Fig. 3a), and also galls on the roots (Fig. 3b). It is very conspicuous because of the woolly excretions (Fig. 3c). I have not collected this gall in Indiana, but it occurs here.



Many of our forest and shade trees are subject to attacks from these insects, which seriously distort them and reduce their vitality.

FAMILY—PSYLLIDÆ.

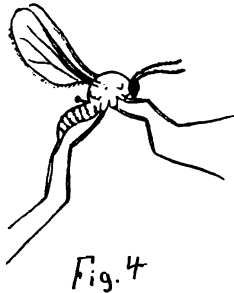
The gall makers of this family are very similar to the Aphididæ, but are not so numerous. They are especially common on the hackberry (*Celtis occidentalis*), but are also found on some other plants.

ORDER—DIPTERA.

Two families of this order produce galls, the *Cecidomyidæ* and the *Trypetidæ*.

FAMILY—CECIDOMYIDÆ.

This is a family of very minute and delicate insects (Fig. 4) which are very numerous and which cause considerable loss of



crops. They are usually easily recognized by the larvæ usually being red or orange colored.

FAMILY—TRYPETIDÆ.

This is the family to which our common housefly belongs and is represented by a single species *Trypeta solidaginis* Fitch (Fig. 36), which produces a hard, spherical gall on our common golden-rods (*Solidago canadensis*).

ORDER—LEPIDOPTERA.

FAMILY—GELECHIIDÆ.

The only gall maker of this order that I have found in the State is *Gnorimoschema gallæsolidaginis* Riley, which produces an elongated hollow gall on our common golden-rods (*Solidago canadensis*) (Fig. 48), but is of no economic importance. A few other species of this order produce galls.

ORDER—COLEPTERA.

FAMILY—BUPRESTIDÆ.

A very few species of this order produce galls. One species, *Agrilus ruficollis* Fabr., is very destructive to the raspberries and blackberries in certain parts of the United States. The eggs are deposited in the canes in July or August and soon hatch; the larvæ immediately bore into the sap wood and cause irregular elongated galls known as the raspberry gouty gall. The winter is passed in the gall and the adult insect emerges in June or July. It is frequently known as the "red-necked *Agrilus*" because of the copper colored thorax which is sharply contrasted with the black wing cover.

ORDER—HYMENOPTERA.

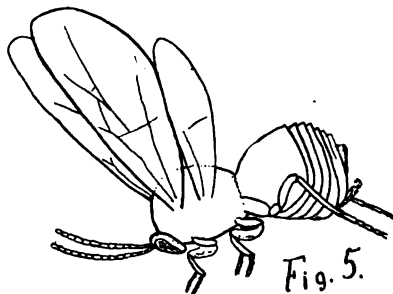
Two families of this order, the *Tenthredinidæ* and the *Cynipidæ* contain a large number of gall makers.

FAMILY—TENTHREDINIDÆ.

Comparatively few species of this family produce galls and I have not collected any of them in Indiana, although I have collected them in Ohio. They are most abundant on the willows.

FAMILY—CYNIPIDÆ.

The members of this family (Fig. 5) produce the most complex of all the insect galls. However, not all the insects of this family produce galls; many of them are not associated with galls,



while others are parasites orinquilines on galls produced by other members of this family. They are most abundant on the various species of the oaks, but are also found on the roses, blackberries and a few other plants.

All galls contain tannin, and in the past have been important articles of commerce. The most important was *Cynips tinctoria* L. of Turkey, which was extensively used and is now occasionally used in medicine as an astringent in the treatment of chronic diarrhoea, chronic dysentery and in poisoning by vegetable alkaloïds. It has also been extensively used in the manufacture of ink, but is now almost entirely supplanted by other methods.

This family has been the subject of some very interesting studies on alterations of generations. In 1861 Baron Osten-Sacken, who was then working in the United States, advanced the theory that the so-called agamous species were sexual but that the males were developed from different galls. This theory proved incorrect, and in 1864 Walsh, an American entomologist, claimed that he had reared from what appeared to be exactly similar galls on one occasion both sexes of *Cynips spongifica* and at another time only females, but that these females were *Cynips aciculata*. These observations were undoubtedly incorrect, and it was not until 1873, after Walsh's death, that Bassett, another American, discovered the true key to the conditions. Bassett observed great numbers of irregular galls on the petioles and midribs of *Quercus bicolor*, and that in June both males and females emerge from them. Also that late in the summer an entirely different shaped gall was formed on the young twigs of the same oak and that from these galls females only emerged the following spring. As a result of these studies Bassett came to the conclusion that the sexual generation caused galls from which emerged the agamous generation and that this generation caused galls from which emerged the sexual generation, thus giving true alternation of generations. He furthermore expressed the idea that it was probable that all species of *Cynips* produced two generations each year.

It, however, remained for Dr. Hermann Adler of Schleswig, Germany, to actually demonstrate that a large number of the *Cynipidæ* did produce two generations, but that a few species were strictly parthenogenetic.

MORPHOLOGY AND EVOLUTION OF INSECT GALLS.

The gall producing species of the Arachnida, Hemiptera and Diptera deposit their eggs on the surface of the plant and after hatching the larvæ penetrate the tissues. The Hymenoptera puncture the tissues and deposit their eggs within the plant.* With the exception of the Tenthredinidæ there is no change in the plant tissues until the hatching of the larvæ. The young larvæ immediately attack the young and growing tissues of the plant and the plant immediately responds by active cell division which results in the formation of a gall.

The form and histological characters of the gall depends upon the order, family and genus to which the insect belongs and not upon the taxonomic position of the plant.

In the Arachnida we find the simplest form of a gall and also galls which are more complex than the simplest Hemiptera galls. The simplest Eriophyidæ galls consist of an abnormal production of trichomes (Fig. 6), among which the minute insects live. The



Fig. 6.

second type is that represented by the *Erineum anomalum*† (Fig. 50) on the walnut; in this case we have a thickening of the tissues resulting in the bending of the petiole or vein of the leaf and the excessive production of trichomes over the surface. The third and most complex type is represented by the formation of a cavity lined with trichomes (Fig. 7) as in the case of *Eriophyes ulmi*, *E. abnormis*, *E. quadripes*, *E. acericola*.

In all cases the cells of the plant lose their normal character, are more numerous, smaller, more compact, and can be separated by a more or less definite boundary into two zones; an inner nutritive zone of very small cells which are very rich in protoplasm, and an outer protective zone of larger cells which contain less protoplasm but considerable quantities of tanin.

The Hemipterous galls range from a very simple leaf curl to the

* The method of deposition of eggs by gall making Coleoptera and Lepidoptera is still an unsettled question.

† Probably *Acarus oaulis* Walsh.

very complex Psyllidæ galls, which are more complex than most of the Dipterous galls. The first type of Hemipterous gall is represented by *Schizoneura Americana* in which we have a wrinkling and curling of the leaf. As in the case of the Eriophyidæ galls, the normal structure of the leaf is lost, the cells are smaller,



Fig. 7

more numerous and less compact and can be separated into two indistinct zones, the nutritive and the protective.

In the second type we have the formation of a pouch of a definite shape (Fig. 40). The cells show the same general morphological character as the preceding, except that the cells are elongated in the direction of the long axis of the gall. Such galls are also well provided with fibro-vascular tissues.

The third and most complex type is found in *Pachysylla celtidis-mammæ* (Figs. 8, 37). In this gall we have a greater dif-

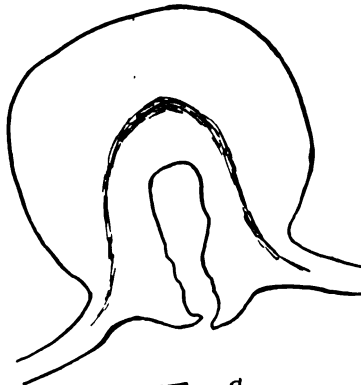


Fig. 8.

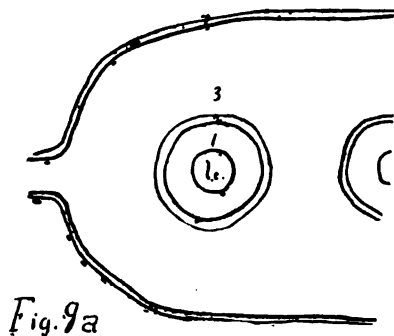
ferentiation of cells resulting in the formation of sclerenchyma cells for the protection of the insect.

Among the Dipterous insects the most conspicuous gall makers belong to the Cecidomyidæ. These galls are so varied in character that it is difficult to divide them into groups with distinct types. However, the same general characters as those just referred to are more or less well defined. If the larvæ does not penetrate the tissues as in the case of *Cecidomyia gleditschiæ* (Fig. 32) the cells become elongated from the midrib to the margin of the leaf, i. e., parallel to the surface of the gall except near the margin, where they are irregular. If the larvæ penetrate the tissues as in the case of *Cecidomyia verrucicola* the mesophyll is at first removed. As the gall increases in size the inner layer of cells divide rapidly and gradually reduce the size of the larval chamber.

The Coleopterous and Lepidopterous galls have not been so thoroughly studied, and I am unable at this time to give any satisfactory discussion of their development.

The Hymenopterous galls, especially the Cynipidæ, present the most complex structures and the most complete line of evolutionary development. The simplest of these galls show the same general characters as the galls previously referred to, i. e., (1) an increase in number of cells which are smaller and more compact than the original mesophyll, and a loss of the palisade cells; (2) separation into two more or less well defined zones.

The second type is well illustrated by *Callirhytis tumifica* (Fig. 9a), in which case we have four rather poorly defined zones; an



inner zone of nutritive cells which are rich in protoplasm, a second zone of small cells corresponding to the protective zones of

the more complex galls, but without the formation of sclerenchyma, a third very thick zone of parenchyma cells and a fourth or outer epidermal zone.

The third type is illustrated by *Amphibolips inanis* (Figs. 9b, 17) in which the four zones are well defined; the second zone developed into well defined sclerenchyma; the third zone separated so that a few cells cling to the sclerenchyma, but the greater part remain attached to the epidermis and the two parts connected by

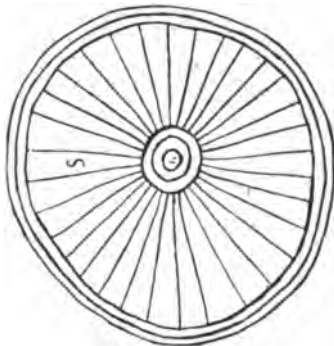


Fig. 9b.

fibro-vascular bundles. The larval chamber is thus surrounded by a nutritive zone which is enclosed by a sclerenchyma zone which is in turn surrounded by a small amount of parenchyma, which is connected with an outer wall of parenchyma and epidermis by means of fibro-vascular bundles.

The fourth type may be illustrated by *Callirhytis papillatus* which is similar to the preceding, except that the larval chambers (two or three in this species) are suspended by single elongated cells.

The fifth type may be illustrated by *Biorhiza forticornis* (Figs.

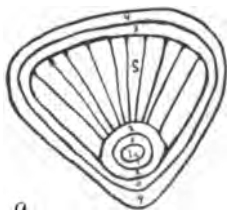


Fig. 9c.

9c, 26), in which the four zones are present, but the separation into inner and outer walls occurs on one side only.

The sixth type may be illustrated by *Amphibolips confluentus* (Fig. 16), in which the four zones may be recognized, but in which the space between the inner and outer walls is bridged by a mixture of fibro-vascular bundles and long filamentous cells.

The seventh type may be illustrated by *Dryophanta palustris* (Fig. 22) in which we have the four well defined zones but the inner wall is entirely separated from the outer, leaving a small body rolling freely within the large hollow sphere which is thus formed by the outer wall.

The origin of these various forms and degrees of complexity is still an obscure problem which becomes more difficult by the introduction of three primary factors. In our consideration of problems of natural selection we ordinarily consider two primary factors, the organism and its environment. The environmental factor may include, and in fact usually does include, several factors, such as climatic conditions and other organisms. In the study of galls, however, we have three primary factors as follows: (1) The gall producer, which is endeavoring to secure food and to provide defense against its many enemies, especially parasites; (2) the host plant, which is endeavoring to withstand the injury produced by the gall maker; (3) the enemies of the gall maker, primarily parasites, inquilines and occasionally small animals which may feed upon the galls.

Adler states that certain European galls produce secretions which are attractive to ants and that these ants defend the gall from parasites. Also, that secretions are frequently produced on tufts of long hair among which the parasites become entangled. These methods do not seem to be of much importance among our native galls.

He also states that the thick parenchyma zone, the dense sclerenchyma tissue of the protective zone, the large size of the gall, and the hollow sphere with the larval chamber suspended in the center are all protective devices which make it difficult for the parasites to reach the larvæ. These methods of protection are very common in our American Cynipidous galls, and I am unable to explain their origin from any other cause. The *Callirhytis tumifica*, *Amphibolips sculpta*, *Holcaspis globulus* and *Amphibolips prunus* illustrate the thickening of the parenchyma zone; *Andricus petiolicola* and *Acraspis crinacei* illustrate the thickening of the

protective or sclerenchyma zone; *Amphibolips confluentus* illustrates the large size; *Amphibolips inanis* and *Holcaspis centricola* illustrate the suspension of the larval chamber in the center of a hollow sphere; and *Dryophanta palustris* illustrates a still more highly developed type by the formation of a free rolling larval chamber within a hollow sphere.

Adler also speaks of the formation of tannin, disagreeable odor, etc., as being protection against birds and other small animals; and the same may be said of our native American galls.

One might readily accept the idea that the "law of natural selection" would develop the two primary factors, the organism and its enemies, the one to defend and the other to attack. However, it is not easy to understand just why a plant should develop a gall for the protection of the gall maker, which is undoubtedly the enemy of the plant. It may be that each species of gall producing insects gives a slightly different stimulus or stimulates slightly different tissues, and that this results in galls of different character. However, granting that there is a slightly different stimulus in each species, we can then understand how a simple gall might have developed complexity which would be protective to the insect; i. e., any variation in the stimulus resulting in a variation in the gall which would be beneficial to the insect would probably be perpetuated in the next generation, while a variation in stimulus resulting in a variation in the gall which would not be beneficial, or would be injurious, would be less likely to be perpetuated in the next generation. Continued variation in stimulus, resulting in variations in galls might eventually result in the formation of a gall of great complexity.

From the preceding observations it appears that in the evolution of the gall there are really but two primary factors, (1) the insect struggling to secure food and defend itself and, (2) its many enemies, also struggling to secure food and thus perpetuate their kind. The host plant is important only in so far as it furnishes more or less suitable conditions for the insect gall maker. However, it presents another problem in that it must in a greater or less degree develop a certain power of resistance against the gall maker.

The gall making habit must have originated independently not only in each of the orders, but also in each of the families represented. In other words, must have arisen independently in at least eleven different points in the insect world.

CAUSES INDUCING GALL FORMATION.

Many theories have been advanced as to the existing factors in the formation of the gall, but up to the present time the evidence leads us to believe that, with the exception of the *Tenthredinidæ*, the stimulus is mechanical rather than chemical.

When the egg is placed within the tissues it is necessary that it be so placed that the larva begin feeding upon the formative cells (Cambium zone) in order that a gall may be produced, and it is probably necessary for the larvæ of those insects which deposit their eggs upon the surface to stimulate the formation of cells in order that a gall may be produced. Up to the present time the observations and studies of other writers as well as my own lead me to believe that, with the exception of the *Tenthredinidæ*, the stimulus is purely mechanical. Adler in his studies upon *Nematus Vallisnerii*, which produces a gall upon *Salix amygdalina* and Beyerinck in his studies of *Nematus coprea*, which also produces a gall upon *S. amygdalina*, came to the conclusion that the gall was produced as the result of a secretion by the parent at the time of depositing the eggs. This seems evident since, according to their observations, the gall commenced before the hatching of the larvæ.

Many of the Cynipidæ also secrete a liquid at the time of depositing the egg, but this does not seem to stimulate gall formation because it is evident that there is no increase in cell formation until the larva emerges from the egg. However, it may be possible that the larva produces certain secretions or that certain excrements given off by it acts as stimuli upon the formative cells of the plant. Mr. W. A. Cannon in discussing a Cecidomyid gall on the Monterey pine (California) says that the "larvæ take their food only by absorption through the surface of the body," also that "there is no indication that the hypertrophy is either caused or affected by any substance deposited with the eggs."

INDIANA GALLS.

This catalogue gives descriptions of 66 species of gall producing insects representing 25 genera and five orders of insects (including Arachnida). The host plants represent ten orders, fourteen families and nineteen genera, as follows:

<i>Orders.</i>	<i>Families.</i>	<i>Genera.</i>
Salicales	Salicaceæ	{ Salix. Populus.
Juglandales	Juglandaceæ	{ Hicoria. Juglans. Quercus.
Urticales	Ulmaceæ	{ Celtis. Ulmus.
Rosales	Hamamelidaceæ	Hamamelis.
	Rosaceæ	{ Rosa. Rubus.
	Caesalpinaceæ	Gleditsia.
	Drupaceæ	Prunus.
Sapindales	Aceraceæ	Acer.
	Anacardiaceæ	Rhus.
Rhamnales	Vitaceæ	Vitis.
Malvales	Tiliaceæ	Tilia.
Gentianales	Oleaceæ	Fraxanus.
Campanulales	Compositæ	Solidago.
Umbellales	Cornaceæ	Cornus.

(The synonymy and bibliography for the following species is fairly complete, except for the family Eriophyidae).

HYMENOPTERA.

CYNIPIDÆ.

RHODITES BICOLOR Harris. Fig. 10.

Cynips bicolor—

T. W. Harris, Treat. Insects Mass., 1841, p. 399.

Osten-Sacken, Stettin. Entom. Zeitg. XXII, 1861, p. 415.

T. W. Harris, Insects Mass., 3d Ed., 1862, p. 548.

Rhodites bicolor—

Osten-Sacken, Proc. Entom. Soc. Philadelphia II, 1863, pp. 43 and 48.

Riley, Amer. Entomol. and Botan. II, 1870, p. 309.

Provancher, Addit. faun. Canada, Hymen, 1886, p. 160.

Ashmead, Bull. I Colo. Biol. Assoc., p. 38, 1890.

Bassett, Trans. Amer. Ent. Soc. 1890, p. 63.

Beutenmüller, Cat. of Gall Insects, 1892, p. 246.

Beutenmüller, Amer. Mus. Jour. Vol. IV, No. 4, p. 6, 1904.

Gillette, Ent. News, Vol. III, p. 246, 1892.

This is a spherical monothalamous gall, about $\frac{1}{4}$ to $\frac{1}{2}$ inch in diameter. It is covered with a great many long slender spines.



Fig. 10.

In the summer it is yellowish green, frequently tinged with red. It is formed singly or in clusters from the leaves, which are frequently completely utilized in its formation. It persists on the twigs throughout the winter. Common on many species of the wild rose. Has wide distribution throughout the United States and Canada.

RHODITES RADICUM Osten-Sacken. Fig. 11.

Rhodites radicum—

- Osten-Sacken, Proc. Entom. Soc. Phil. II, 1863, p. 42 and 46.
 Riley, 1st Ann. Rep. Insects of Missouri, 1869, p. 13.
 Riley, Amer. Entomol. and Botan. II, 1870, p. 181.
 Riley, Ins. Inj. Veg., p. 304, 1883.
 Ashmead, Bull. I, Colo. Biol. Assoc., p. 38, 1890.
 Bassett, Trans. Amer. Ent. Soc. 1890, p. 62.
 Webster, Ohio Agri. Ex. Station. Bull. 45, 1892.
 Beutenmüller, Cat. of Gall Insects, 1892, p. 246.
 Beutenmüller, Amer. Mus. Jour. Vol. IV, No. 4, 1904, p. 6.
 Gillette, Ent. News, Vol. III, p. 246, 1892.

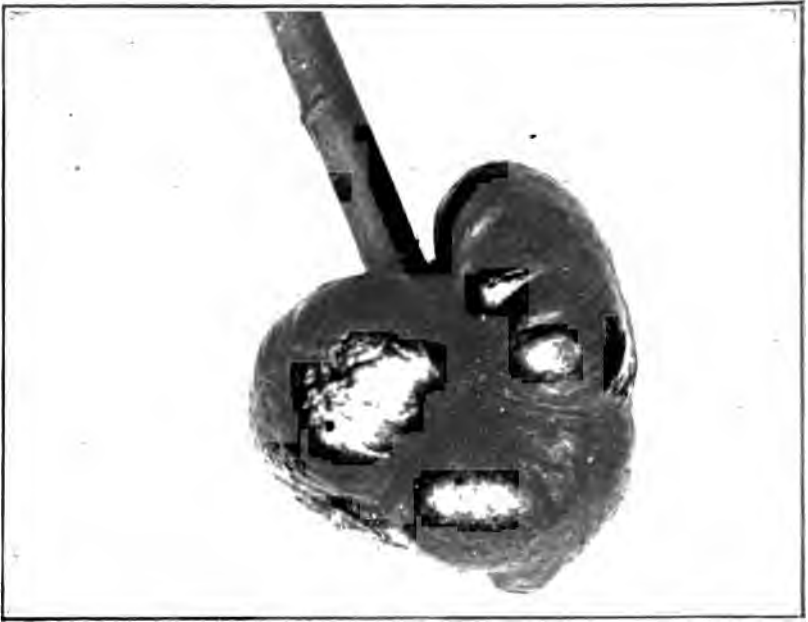


Fig. 11.

A large, irregular, smooth, reddish brown polythalamous gall, frequently two inches in diameter, surrounding the root of the wild rose, with a deep depression both above and below at its place of attachment. Common in many States. A single Indiana specimen was sent to me by Mr. F. C. Senour, of New Augusta, Indiana, collected on *Rosa carolina* L.

RHODITES GLOBULUS Beutenmüller. Fig. 12.

Rhodites globulus—

Beutenmüller, Cat. of Gall Insects, 1892, p. 247.

Beutenmüller, Amer. Mus. Jour. Vol. IV, No. 4, 1904, p. 7.

This gall is smooth, polythalamous, spherical or oblong, encircles the branch of our *Rosa carolina*. About $\frac{3}{4}$ inch to $1\frac{1}{2}$ inches in diameter. Can be readily distinguished from *Rhodites radicum* by its being on the twigs instead of on the roots, much smaller, and by the fact that it is not depressed at the points of its contact with the stem. Only previous record from New York.*

* Probably described by Osten-Sacken in Proc. Ent. Soc. Phil. Vol. II., p. 42.



Fig. 12.

RHODITES DICHLOCERUS Harris. Fig. 13.*Cynips dichlocerus*—

T. W. Harris, Treat. Insects Mass., 1841, p. 399.

Osten-Sacken, Stettin. Entom. Zeitg. XXII, 1861, p. 415.

T. W. Harris, Treat. Insect. Mass., 3d Ed., 1862, p. 549.



Fig. 13.

Rhodites dichlocerus—

Osten-Sacken, Proc. Entom. Soc. Phil. II, 1863, p. 42 and 46.

Ashmead, Trans. Amer. Ent. Soc. Vol. XIV, 1887, p. 148.

Beutenmüller, Cat. of Gall Insects, 1892, p. 247.

Beutenmüller, Amer. Mus. Jour. Vol. IV, No. 4, p. 7.

This gall is an elongated, spindle-shaped, woolly swelling of the stems, about 1 to 1½ inches in length. Common on *Rosa carolina* in many States.

DIASTROPHUS CUSCUTÆFORMIS Osten-Sacken. Fig. 14.*Diastrophus cuscutæformis*—

Osten-Sacken, Proc. Ent. Soc. Phil. Vol. II, pp. 39, 45.

Webster, Ohio Agri. Ex. Stat. Bull. 45, 1892, p. 156.

Beutenmüller, Cat. of Gall Insects, 1892, p. 249.

Beutenmüller, Amer. Mus. Jour. Vol. IV, No. 4, p. 9, 1904.



Fig. 14.

Small, globular, monothalamous, stem gall provided with one or more spines. Usually in groups and closely pressed together. A single specimen on *Rubus villosus* collected in Steuben County by Prof. W. A. Kellerman, of the Ohio State University. Known to occur in New York and Maryland.

DIASTROPHUS NEBULOSUS Osten-Sacken. Fig. 15a, b.*Cynips (Diastrophus?) nebulosus*—

Osten-Sacken, Stettin. Entom. Zeitg. XXII, 1861, p. 415.

Diastrophus nebulosus—

Osten-Sacken, Proc. Ent. Soc. Phil. Vol. II, 1863, p. 36.

Riley, Amer. Ent. Vol. II, 1870, p. 159-160.

Fuller, Amer. Ent. Vol. III, 1880, p. 63.

Provancher, Natural. Canad. XII, 1881, p. 235.

Provancher, Faun. entom. Canada. Hymen, 1883, p. 550.

Ashmead, Trans. Amer. Ent. Soc. Vol. XIV, 1887, p. 148.

Saunders, Ins. Inj. to Fruit, p. 318.

Webster, Ohio Agri. Ex. Stat. Bull. 45, 1892, p. 157.

Slosson, Ent. News, Vol. VIII, p. 237, 1897.

Beutenmüller, Cat. of Gall Insects, 1892, p. 249.

Beutenmüller, Amer. Mus. Jour. Vol. IV, No. 4, 1904, p. 9.

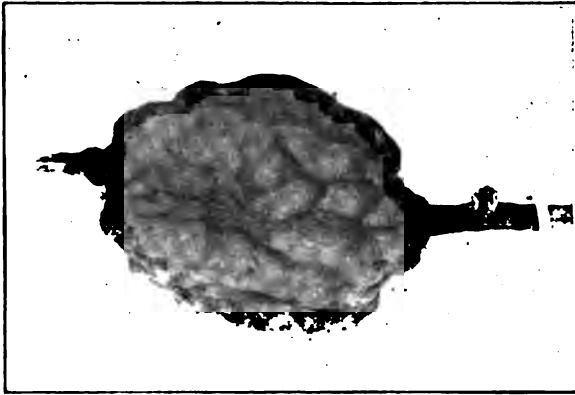


Fig. 15a.

A very large, oblong, polythalamous, stem gall with deep longitudinal grooves, 1 to 3 inches in length, and 1 to 1½ inches in diameter. A dark green, gradually becoming reddish brown with the approach of spring. The insect emerges in the spring of the year following the formation of the gall. Common on *Rubus villosus*.

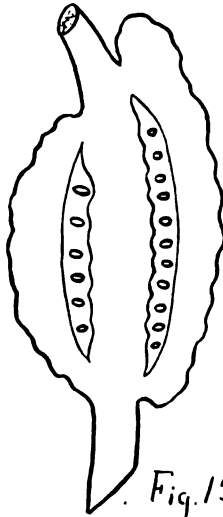


Fig. 15b.

AMPHIBOLIPS CONFLUENTUS Harris. Fig. 16.*Cynips confluentus*—

Harris, Rep. Ins. Inj. Veget. 1st Ed., 1841, p. 397.

Harris, Rep. Ins. Inj. Veget. 2d Ed., 1852, p. 433.

Harris, Rep. Ins. Inj. Veget. 3d Ed., 1862, p. 546.

Osten-Sacken, Proc. Ent. Soc. Phil. Vol. I, p. 53.

Walsh, Proc. Ent. Soc. Phil. Vol. II, p. 481.

Cynips aciculata—

Osten-Sacken, Proc. Ent. Soc. Phil. Vol. I, pp. 56 and 245.

Osten-Sacken, Proc. Ent. Soc. Phil. Vol. IV, p. 354.

Walsh, Proc. Ent. Soc. Phil. Vol. II, pp. 443, 462, 481.

Walsh, Am. Ent. Vol. II, p. 330.

Walsh & Riley, Am. Ent. Vol. I, p. 103.

**Fig. 16.***Cynips coccineæ*—

Osten-Sacken, Proc. Ent. Soc. Phil. Vol. I, pp. 243, 248.

Osten-Sacken, Proc. Ent. Soc. Phil. Vol. IV, p. 354.

Walsh, Proc. Ent. Soc. Phil. Vol. II, p. 481.

Amphibolips coccineæ—

Ashmead, Trans. Am. Ent. Soc. Vol. XII, p. 294.

Packard, 5th Rep. U. S. Ent. Com., p. 104.

Cynips spongifica—

- Osten-Sacken, Proc. Ent. Soc. Phil. Vol. I, pp. 244, 248.
 Osten-Sacken, Proc. Ent. Soc. Phil. Vol. IV, p. 347.
 Walsh, Proc. Ent. Soc. Phil. Vol. II, p. 443, 452.
 Walsh, Am. Ent. Vol. II, p. 330.
 Walsh & Riley, Am. Ent. Vol. I, p. 103.

Amphibolips spongifica—

- Ashmead, Trans. Am. Ent. Soc. Vol. XII, p. 294.
 Gillette, 27th Mich. Agri. Rep., 1888.
 Packard, 5th Rep. U. S. Ent. Com., p. 104.

Amphibolips confluentus—

- Beutenmüller, Cat. of Gall Insects, 1892, p. 250.
 Beutenmüller, Amer. Mus. Jour. Vol. IV, No. 4, 1904, p. 10.

This is a spherical, smooth-leaf gall with thin wall. Inside it is filled with a spongy substance, in the center of which is a dense walled chamber containing a single large larva. This gall is 1 to 2 inches in diameter and of a pale green color. Late in the season it becomes brown and is very dry and brittle. This species presents a good example of dimorphism. Osten-Sacken describes both male and female coming from these galls in June. These he calls *Cynips (Amphibolips) spongifica*. He also describes a later brood of females only coming forth in October or the following spring, and these he named *Cynips (Amphibolips) acculata*. But B. D. Walsh demonstrated that the second brood was merely a brood of polymorphic females. This species occurs on *Quercus tinctoria*, *Q. rubra*, *Q. coccinea*, and *Q. nigra*.

AMPHIBOLIPS INANIS Osten-Sacken. Fig. 17.*Callaspida confluens*—

- Fitch, 5th Rep. Nox. Ins. Trans. N. Y. State Agri. Soc., 1858, p. 817.

Cynips inanis—

- Osten-Sacken, Proc. Entom. Soc. Phil. I, p. 58.
 Osten-Sacken, Proc. Entom. Soc. Phil. II, p. 242.
 Walsh, Proc. Entom. Soc. Phil. III, p. 403.
 Walsh, Proc. Entom. Soc. Phil. II, pp. 457, 458, 481.
 Osten-Sacken, Proc. Entom. Soc. Phil. IV, p. 354.
 Walsh & Riley, Amer. Entomol. I, p. 104.
 Riley, 1st Ann. Rep. Insects, Missouri, p. 14.

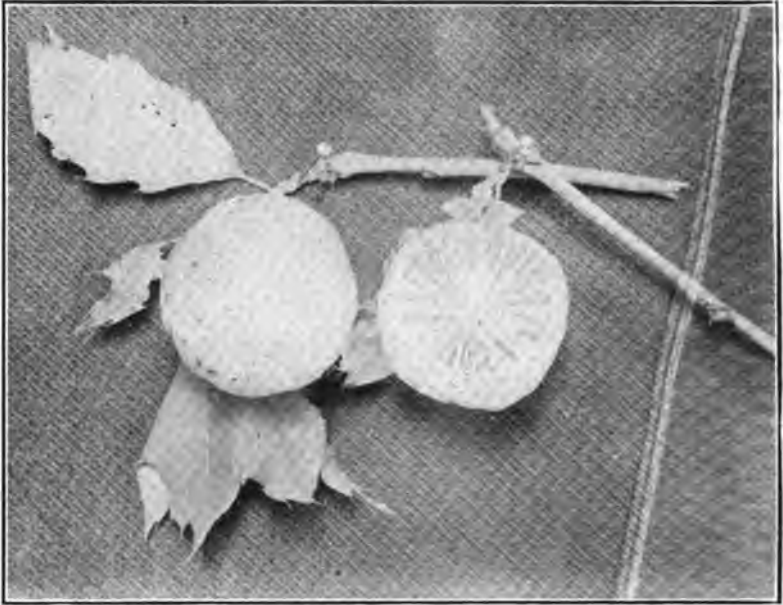


Fig. 17.

Amphibolips inanis—

Mayr, 20, Jahresber, Comm. Oberralsch I, Bez. Wien, 1881, p. 27.

Gillette, 27th Mich. Agri. Rep., 1888.

Gillette, Psyche V, p. 184.

Ashmead, Trans. Amer. Ent. Soc. Vol. XII, p. 294.

Packard, 5th Report U. S. Ent. Comm. 1890, p. 105.

Beutenmüller, Cat. of Gall Insects 1892, p. 251.

Beutenmüller, Amer. Mus. Jour. Vol. IV, No. 4, 1904, p. 11.

This is a spherical gall with thin outer wall. In the center is a larval chamber which is supported by filaments which radiate to the outer wall. This gall is from $\frac{1}{2}$ to 1 inch in diameter, light green in color, with a number of small black dots on the surface. Occurs on *Quercus coccinea* and *Q. rubra*.

AMPHIBOLIPS PRUNUS Walsh. Fig. 18.*Cynips prunus*—

Walsh, Proc. Entom. Soc. Phil. III, p. 639.

Walsh & Riley, Amer. Entomol. I, p. 104.

Amphibolips prunus—

Mayr, 20 Jahresber. Comm. Oberrealsch I, Bez. Wien, 1881, p. 27.

Gillette, Psyche V, 1889, p. 184.

Ashmead, Trans. Amer. Ent. Soc. Vol. XIV, 1887, p. 130.

Lintner, 4th Rep. Insects New York 1888, p. 42, 44.

Packard, 5th Rep. U. S. Ent. Com., p. 105.

Beutenmüller, Cat. of Gall Insects, 1892, p. 252.

Beutenmüller, Amer. Mus. Jour. Vol. IV, No. 4, p. 12, 1904.



Fig. 18.

This is an oval, fleshy, but solid, monothalamous gall found growing from the side of the acorn. It is a bright red, gradually shading into yellow towards the center. The gall is $\frac{1}{2}$ to 1 inch in diameter. The insect comes out in the late spring of the year following the formation of the gall. A single specimen was sent to me by Mr. F. C. Senour, of New Augusta, Indiana. I was unable to determine the species of the host, but it is reported from other states to occur on *Quercus rubra* and *Q. tinctoria*.

AMPHIBOLIPS SCULPTA Bassett.

Cynips sculpta—

Bassett, Proc. Entom. Soc. Phil. II, p. 324.

Cynips sculpta—

Walsh, Proc. Entom. Soc. Phil. II, p. 84.

Osten-Sacken, Proc. Entom. Soc. Phil. IV, p. 356.

Amphibolips sculpta—

Mayr, 20 Jahresber. Comm. Oberrealsch I, Bez. Wien, 1881,
p. 27.

Gillette, Psyche V, p. 184.

Gillette, Proc. Iowa Acad. Sci. Vol. I, pt. 2, p. 111, 1892.

Gillette, 27th Mich. Agri. Rep. pp. 468, 477, 1888.

A smooth, spherical, soft, succulent, monothalamous leaf gall about $\frac{1}{2}$ to $\frac{3}{4}$ inches in diameter and very much resembling green grapes. Specimens growing on *Quercus rubra* were collected near Laporte, Indiana, by Mr. Fred L. Sims. It is also said to occur on *Quercus tinctoria*.

ANDRICUS SEMINATOR Harris. Fig. 19.*Cynips seminator*—

Harris, Rep. Ins. Inj. Veget. 1st Ed., 1841, p. 399.

Harris, Rep. Ins. Inj. Veget. 2d Ed., 1852, p. 434.

Fitch, 5th Rep. Nox. Ins. Trans. N. Y. Agricul. Soc. 1858,
pp. 315, 813.

Osten-Sacken, Proc. Entom. Soc. Phil. I, 1861, p. 69.

Osten-Sacken, Stettin. Entom. Zeitg. XXII, 1861, p. 410.

Harris, Rep. Ins. Inj. Veget. 3d Ed., 1862, p. 548.

Walsh, Proc. Entom. Soc. Phil. II, 1863, p. 465.

Walsh, Proc. Entom. Soc. Phil. II, 1864, pp. 489, 490.

Cynips (Andricus) seminator—

Osten-Sacken, Proc. Entom. Soc. Phil. IV, 1865, p. 351.

Cynips seminator—

Walsh & Riley, Amer. Entomol. II, 1869, p. 71.

Andricus (Callirhytis) seminator—

Mayr, 20 Jahresber. Comm. Oberrealsch I, Bez. Wien, 1881,
p. 28.

Andricus seminator—

Gillette, Psyche V, 1889 p. 185.

Gillette, 27th Mich. Agri. Rep., pp. 468 and 477, 1888.

Cynips seminator—

Packard, Rep. U. S. Entom. Comm. V, 1890.

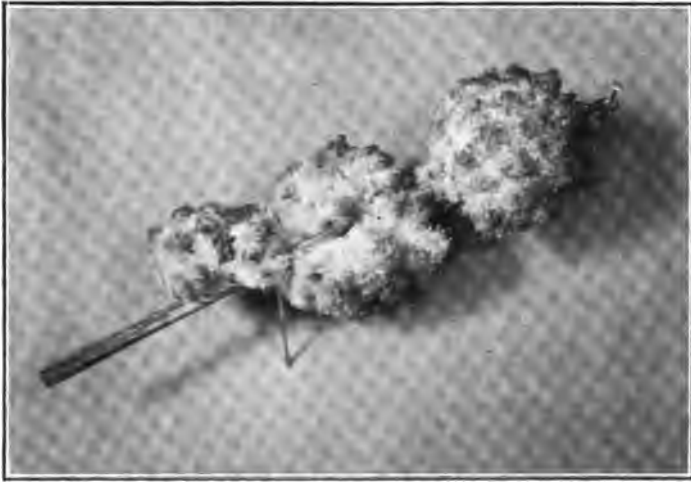


Fig. 19.

Andricus (Callirhytis) seminator—

Beutenmüller, Cat. of Gall Insects, 1892, p. 254.

Beutenmüller, Amer. Mus. Jour. Vol. IV, No. 4, 1904, p. 13.

Andricus seminator—

Gillette, Proc. Iowa Acad. Sci. Vol. I, pt. 2, p. 111, 1892.

A very small, monothamous, compound gall. These galls are always collected in masses and covered with a woolly substance which gives the mass a more or less spherical appearance. This mass varies from 1 to 2 inches in diameter and is either pure white or tinged with red, but late in the autumn becomes rusty brown. Very common on *Quercus alba*.

ANDRICUS PAPILLATUS Osten-Sacken. Fig. 20.

Cynips papillata—

Osten-Sacken, Proc. Entom. Soc. Phil. I, p. 64.

Osten-Sacken, Stettin. Entom. Zeitg. XXII, 1861, p. 409.

Cynips (Andricus) papillatus—

Osten-Sacken, Proc. Entom. Soc. Phil. IV, 1865, p. 352.

Andricus (Callirhytis) papillatus—

Ashmead, Trans. Amer. Entom. Soc. XII, 1885, p. 295.

Packard, 5th Rep. U. S. Ent. Com., p. 105.

Beutenmüller, Cat. of Gall Insects, p. 255.

Beutenmüller, Amer. Mus. Jour. Vol. IV, No. 4, 1904, p. 14.

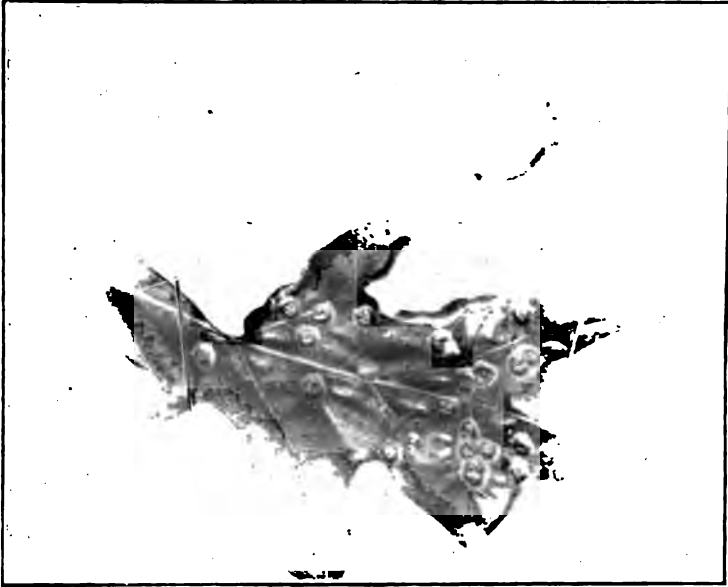


Fig. 20.

Small gall projecting from both surfaces of the leaf. In the center are two or three chambers each containing a single larva. These chambers are suspended by filaments which radiate to the outer wall. Each gall is about $\frac{1}{8}$ to $\frac{1}{4}$ inch in diameter. Common on the oaks.

ANDRICUS CLAVULA Bassett. Fig. 21.

Cynips arbor—

Fitch, 5th Rep. Nox. Ins. Trans. N. Y. Agricul. Soc., 1858,
p. 809.

Bassett, Proc. Ent. Soc. Phil. Vol. III, p. 686.

Cynips tuber—

Bassett, Proc. Ent. Soc. Phil. Vol. III, p. 685.

Cynips clavuli—

Bassett, Proc. Ent. Soc. Phil. Vol. IV, p. 351.

Osten-Sacken, Proc. Ent. Soc. Phil. Vol. IV, p. 379.

Andricus (Callirhytis) clavula—

Mayr, 20 Jahresber. Comm. Oberrealsch I, Bez. Wien, 1881,
p. 28.

Bassett, Am. Nat. Vol. XVI, p. 246.

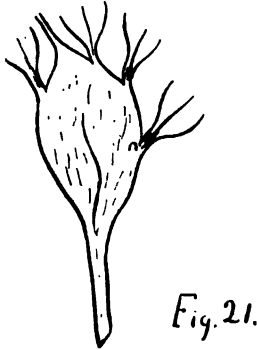
Ashmead, Trans. Am. Ent. Soc. Vol. XII, p. 294.

Packard, 5th Rep. U. S. Ent. Com., p. 105.

Andricus clavula—

Gillette, Psyche V, 1889, p. 184.

Gillette, 27th Mich. Agri. Rep., 1888.



Andricus (Callirhytis) clavula—

Beutenmüller, Cat. of Gall Insects, 1892, p. 255.

Beutenmüller, Amer. Mus. Jour. Vol. IV, No. 4, 1904, p. 15.

A club shaped gall formed from the bud at the tip of the twig. Green in summer but in winter same color as twig. Common on *Quercus alba*.

ANDRICUS PALUSTRIS Osten-Sacken. Fig. 22.

Cynips palustris—

Osten-Sacken, Proc. Ent. Soc. Phil. Vol. I, p. 62; Vol. III, p. 359.

Osten-Sacken, Trans. Am. Ent. Soc. Vol. III, p. 54.

Andricus (Callirhytis) palustris—

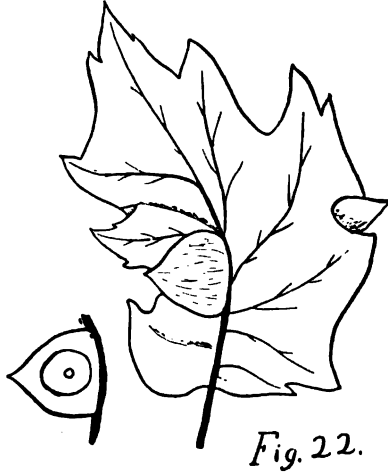
Bassett, Am. Nat. Vol. XVI, p. 246.

Ashmead, Trans. Am. Ent. Soc. Vol. XII, p. 294.

Packard, 5th Rep. U. S. Ent. Com., p. 105.

Beutenmüller, Cat. of Gall Insects, 1892, p. 256.

Beutenmüller, Amer. Mus. Jour. Vol. IV, No. 4, p. 15, 1904.



A smooth, spherical, green, succulent leaf gall about $\frac{1}{2}$ inch in diameter. The inside is hollow, with a small whitish, globular body about 1-10th inch in diameter. This small body rolls freely and contains a single chamber with a single larva. The adult insect comes out in May. Common on *Quercus palustris*.

ANDRICUS PETIOLICOLA Bassett. Fig. 23.

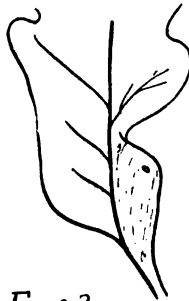
Cynips petiolicola—

Bassett, Proc. Entom. Soc. Phil. II, 1863, p. 325.

Walsh, Proc. Entom. Soc. Phil. II, 1864, p. 487.

Cynips petiolicola—

Gillette, Psyche V, 1889, p. 1862.



Cynips (Andricus) petiolicola—

Osten-Sacken, Proc. Ent. Soc. Phil. Vol. IV, p. 379.

Bassett, Am. Nat. Vol. XVI, p. 246.

Ashmead, Trans. Am. Ent. Soc. Vol. XII, p. 295.

Gillette, 27th Mich. Agri. Rep., 1888.

Packard, 5th Rep. U. S. Ent. Com., p. 105.

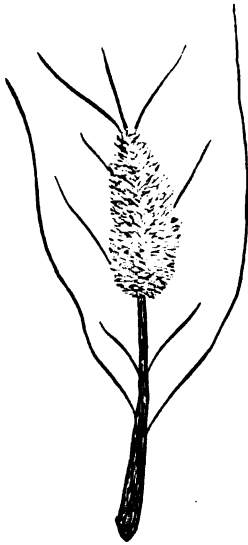
Beutenmüller, Cat. of Gall Insects, 1892, p. 257.

Beutenmüller, Amer. Mus. Jour. Vol. IV, No. 4, 1904, p. 16.

A dense, woody, club shaped, polythalamous gall on the petiole or midrib of the leaf of *Quercus alba*, *Q. prinus*, *Q. bicolor*, *Q. obtusiloba*.

ANDRICUS LANA Fitch. Fig. 24.*Cynips lana*—

Fitch, 5th Rep. Nox. Trans. N. Y. State Agricul. Soc., 1858, p. 814.

*Fig. 24.**Andricus lana*—

Ashmead, Trans. Am. Ent. Soc. Vol. XII, p. 295.

Packard, 5th Rep. U. S. Ent. Com., p. 105.

Beutenmüller, Cat. of Gall Insects, 1892, p. 257.

Beutenmüller, Amer. Mus. Jour. Vol. IV, No. 4, 1904, p. 16.

Numerous, small and collected in a mass on one of the principal veins and covered with a white or buff colored woolly mass. Common on *Quercus rubus* and *Q. alba*.

ANDRICUS FEMORATUS Ashmead.

Andricus femoratus—

Ashmead, Trans. Amer. Entom. Soc. XIV, 1887, p. 141.

A small, thin walled spherical gall. In the center is a single small chamber held in place by fine radiating filaments. On *Quercus rubra*.

CYNIPS PISUM Fitch.

Cynips pisum—

Fitch, 5th Rep. Nox. Ins. N. Y. Trans. Agri. Soc. XVIII, p. 818.

Osten-Sacken, Proc. Entom. Soc. Phil. I, 1861, p. 59.

Osten-Sacken, Proc. Entom. Soc. Phil. I, 1862, p. 250.

Osten-Sacken, Proc. Entom. Soc. Phil. IV, 1865, p. 361.

Ashmead, Trans. Am. Ent. Soc. Vol. XII, p. 303.

Beutenmüller, Cat. of Gall Insects, 1892, p. 258.

Beutenmüller, Amer. Mus. Jour. Vol. IV, No. 4, 1904, p. 18.

Spherical, polythalamous gall. The surface finely netted with depressions between which are small elevations. About $\frac{1}{2}$ inch in diameter and pale greenish yellow in color. Attached to veins on either under or upper surface of the leaf. Common on *Quercus alba*.

ACRASPID ERINACEI Walsh. Fig. 25.

Cynips erinacei—

Walsh, Proc. Ent. Soc. Phil. Vol. II, p. 483.

Cynips erinaceus—

Osten-Sacken, 7th Rep. U. S. Geol. and Geog. Sur., 1873, 1874.

Acraspis erinacei—

Mayr, 20 Jahresber. Comm. Oberrealsch I, Bez Wein, 1881, p. 29.

Mayr, Genera der Gallben. Cynipid, p. 29.

Bassett, Am. Nat. Vol. XVI, p. 246.

Ashmead, Trans. Am. Ent. Soc. Vol. XII, p. 295.

Ashmead, Bull. No. 3, Kans. Agri. Ex. Station, App., p. IV, 1888.

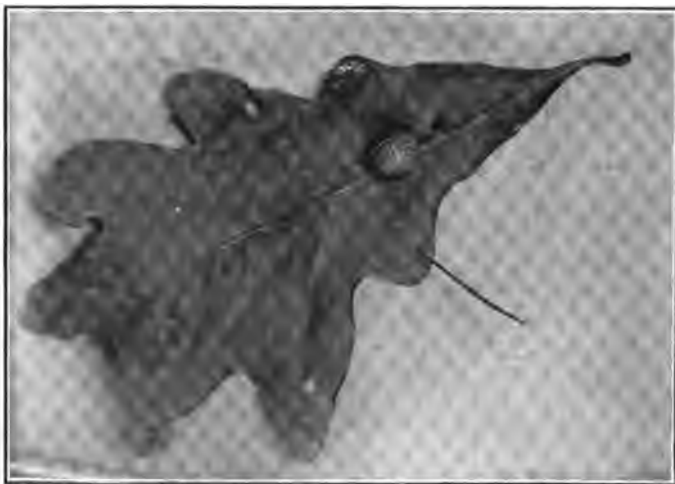


Fig. 25.

Ashmead, Bull. No. 1, Colo. Biol. Assoc., p. 38.

Packard, 5th Rep. U. S. Ent. Com., p. 106.

Gillette, 27th Mich. Agri. Ex. Station Rep., pp. 470-477, 1888.

Gillette, Psyche V, 1889, p. 186.

Gillette, Proc. Ia. Acad. Sci. Vol. I, pt. 2, p. 112, 1892.

Beutenmüller, Cat. of Gall Insects, 1892, p. 259.

Beutenmüller, Amer. Mus. Jour. Vol. IV, No. 4, 1904, p. 18.

An oval, polythalamous gall, $\frac{1}{4}$ to $\frac{1}{2}$ inch in diameter, and attached by a single point to the rib on the upper surface of the leaf. Finely netted with fissures and covered with long spines of a bright red color. Common on *Quercus rubra*.

XANTHOTERAS FORTICORNIS Ashmead. Fig. 26.

Cynips ficus—

Fitch, 5th Rep. Nox. Ins. Trans. N. Y. Agri. Soc., 1858, p. 812.

Osten-Sacken, Pro. Ent. Soc. Phil. Vol. IV, p. 368.

Cynips forticornis—

Walsh, Proc. Ent. Soc. Phil. Vol. II, p. 490.

Teras forticornis—

Osten-Sacken, Pro. Ent. Soc. Phil. Vol. IV, p. 379.

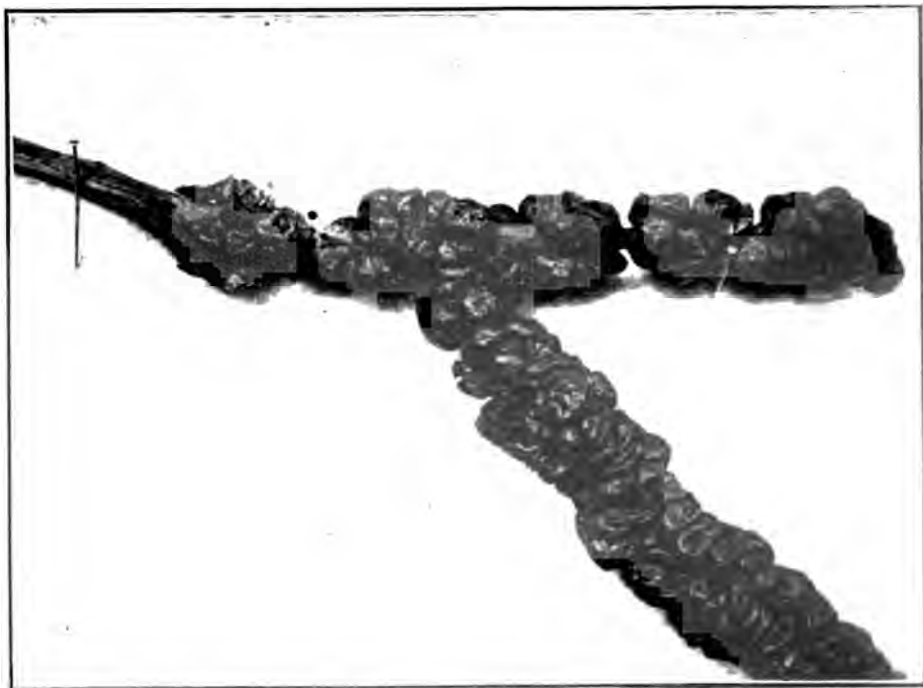


Fig. 26.

Acraspis forticornis—

Bassett, Am. Nat. Vol. XVI, p. 246.

Ashmead, Trans. Am. Ent. Soc. Vol. XII, p. 296.

Packard, 5th Rep. U. S. Ent. Com., p. 107.

Biorhiza forticornis—

Mayr, 20 Jahresber. Comm. Oberrealsch I, Bez. Wien, 1881,
p. 32.

Gillette, 27th Mich. Agri. Rep., pp. 470 and 477.

Gillette, Psyche V, 1889, p. 186.

Gillette, Proc. Iowa Acad. Sci. Vol. I, pt. 2, p. 113.

Ashmead, Bull. I, Colo. Biol. Assoc., p. 38, 1890.

Beutenmüller, Cat. of Gall Insects, p. 259, 1892.

Beach, Proc. Iowa Acad. Sci. II, p. 94, 1895.

Xanthoteras forticornis—

Ashmead, Psyche X, p. 149, 1903.

Small fig-shaped galls, closely packed in dense clusters around the young twigs. An inner chamber containing a single larva is

fastened directly to one side of the outer wall and on the other side is connected with the outer wall by means of filaments. It is pale yellow, often tinged with red, but in winter becoming brown. Frequently on *Quercus alba*.

HOLCASPIS GLOBULUS Fitch. Fig. 27.

Callaspidia globulus—

Fitch, 5th Rep. Nox. Ins. N. Y. State Agricul. Soc., 1858, p. 811.

Packard, 5th Rep. U. S. Ent. Com., p. 111.

Cynips globulus—

Fitch, 5th Rep. Nox. Ins. N. Y. State Agri. Soc., p. 312.

Osten-Sacken, Proc. Ent. Soc. Phil., Vol. I, p. 67.

Osten-Sacken, Stettin. Entom. Zeitg. XXII, 1861, p. 410.

Bassett, Proc. Entom. Soc. Phil., Vol. II, p. 328.

Walsh, Proc. Entom. Soc. Phil., Vol. II, p. 488.

Cynips globuli—

Osten-Sacken, Proc. Entom. Soc. Phil., Vol. IV, p. 350.

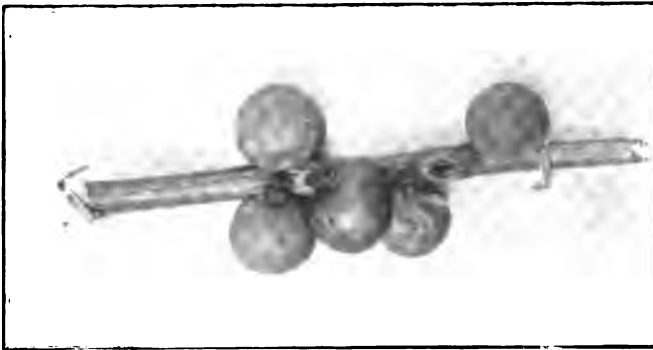


Fig. 27.

Holcaspis globulus—

Mayr, 20 Jahresber. Comm. Oberrealsch I, Bez. Wien, 1881, p. 35.

Bassett, Am. Nat. Vol. XVI, p. 246.

Packard, 5th Rep. U. S. Ent. Com., p. 106.

Gillette, 27th Mich. Agri. Rep., pp. 470 and 478, 1888.

Gillette, Psyche V, 1889, p. 187.

Gillette, Proc. Iowa Acad. Sci. Vol. I, pt. 2, p. 113, 1892.

Beutenmüller, Cat. of Gall Insects, 1892, p. 260.

Beutenmüller, Amer. Mus. Jour. Vol. IV, No. 4, 1904, p. 19.

Patton, Ent. News III, p. 104.

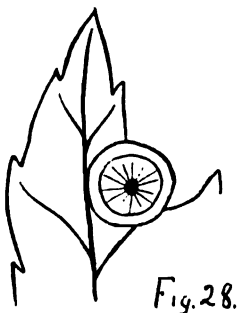
Spherical, smooth, corky, monothalamous, twig galls. The larva is contained in oval white, shell-like central structures. Yellow, frequently tinged with red, but brown in winter. One-half to three-fourths inch in diameter. Common on *Quercus alba*.

HOLCASPIS CENTRICOLA Osten-Sacken. Fig. 28.

Cynips centricola—

Osten-Sacken, Proc. Entom. Soc. Phil. I, 1861, p. 58.

Osten-Sacken, Proc. Entom. Soc. Phil. IV, 1865, p. 350.



Holcaspis centricola—

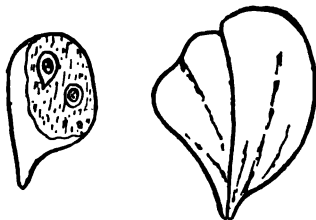
Ashmead, Trans. Amer. Entom. Soc. XII, 1885, p. 296.

A spherical gall very similar to *Amphibolips inanis* O.-S., except that it is smaller and in fact might be very easily mistaken for *A. inanis*. On *Quercus obtusiloba*.

DRYOPHANTA RADICOLA Ashmead. Fig. 29.

Dryophanta radicola—

Ashmead, Proc. of the U. S. Nat. Mus. Vol. XIX, p. 116, 1896.



A fig-shaped, polythalamous gall produced in a cluster on the stem just below the surface of the ground. Yellow and when partly exposed to the sun becomes bright red. On *Quercus alba*.

NEUROTERUS RILEYI Bassett. Fig. 30.

Cynips sp.———

J. A. W., Amer. Entomol. III, 1880, p.153.

Cynips Rileyi—

Bassett, Amer. Nat. XV, 1881, p. 149.

Packard, Rep. U. S. Entom. Com. V, 1890, p. 114.

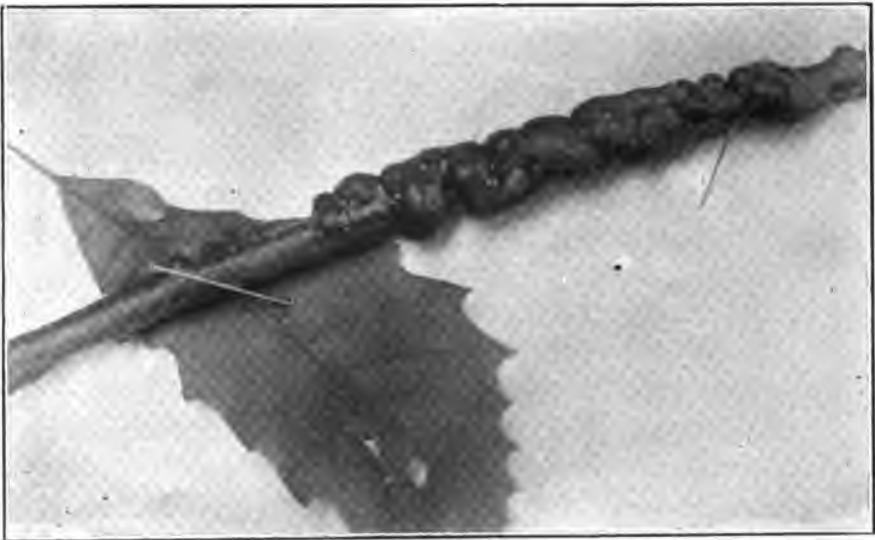


Fig. 30.

Neuroterus Rileyi—

Mayr, 20 Jahresber. Com. Oberrealsch I, Bez. Wien, 1881,
p. 37.

Clustered swellings on the young stems of *Quercus prunus*. Each gall is polythalamous. Forms in the late summer and the flies emerge the following spring.

CALLIRHYTIS TUMIFICA Osten-Sacken.

Callirhytis tumifica—

Osten-Sacken, Proc. Entom. Soc. Phil., 1865, p. 356.

A fleshy polythalamous leaf gall extending on both surfaces of the leaf. One-eighth to $\frac{1}{4}$ inch, rarely $\frac{1}{2}$ inch in diameter. Common on *Quercus tinctoria* and *Q. alba*.

DIPTERA.

CECIDOMYIDÆ.

CECIDOMYIA VERRUCICOLA Osten-Sacken.

Cecidomyia verrucicola—

Osten-Sacken, Can. Ent. Vol. VII, p. 200.

Beutenmüller, Cat. of Gall Insects, 1892, p. 264.

Beutenmüller, Amer. Mus. Jour. Vol. IV, No. 4, 1904, p. 24.

A small gall projecting from both surfaces of the leaf. About 1-5 inch in diameter. In the fall it opens on the under side by means of a circular lid which frequently remains attached by one edge. Common on *Tilia Americana*. Reported from New York; probably very widely distributed.

CECIDOMYIA CERASI-SEROTINÆ Osten-Sacken.

Cecidomyia cerasi-serotinæ—

Osten-Sacken, Trans. Am. Ent. Soc. Vol. III, p. 346.

Beutenmüller, Cat. of Gall. Insects, 1892, p. 265.

Beutenmüller, Amer. Mus. Jour. Vol. IV, No. 4, 1904, p. 25.

A more or less spherical, fleshy gall formed from the terminal bud. Bright red in color and frequently with one or two leaves growing from the side. Rare. Also reported from New York. On *Prunus serotina*.

CECIDOMYIA PELLEX Osten-Sacken. Fig. 31.

Cecidomyia peller—

Osten-Sacken, Mon. Dipt. N. Am., pt. 1, p. 199.

Beutenmüller, Cat. of Gall Insects, 1892, p. 265.

Beutenmüller, Amer. Mus. Jour. Vol. IV, No. 4, 1904, p. 26.

I am not sure that my determination of this gall is correct. It is formed as a result of the swelling of the petiole of the midrib of the leaflets. Frequently the entire leaflet is destroyed leaving a cluster of bean-shaped structures. The larvæ leave the gall in the latter part of June and early in July. Common on *Fraxinus Americana*.

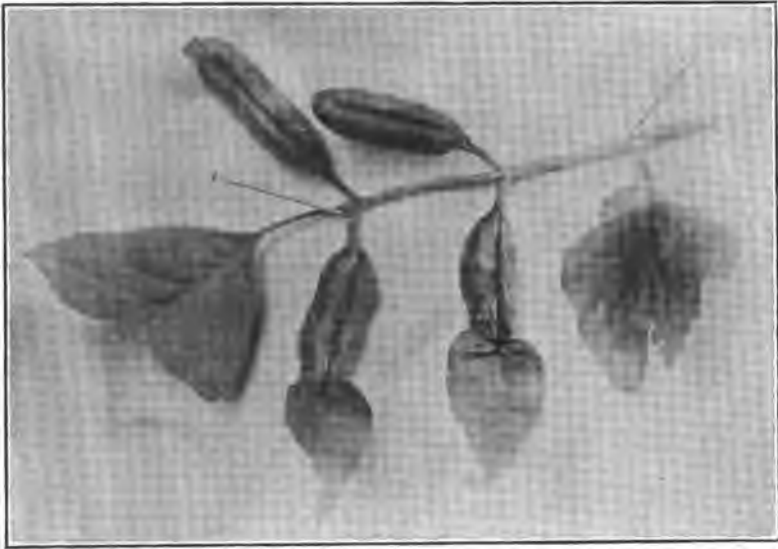


Fig. 31.

CECIDOMYIA GLEDITSCHIE Osten-Sacken. Fig. 32.

Cecidomyia gleditschie--

Osten-Sacken, Proc. Ent. Soc. Phil. Vol. VI, p. 219.

Beutenmüller, Cat. of Insect Galls, 1892, p. 266.

Beutenmüller, Amer. Mus. Jour. Vol. IV, No. 4, 1904, p. 26.

The leaflets are so folded along the central vein that the edges are brought together, forming a pod. Sometimes only the tip of



Fig. 32.

the leaflet is thus deformed. The life history is completed within the gall and the adult insect emerges in June and July. Common on *Gleditschia triacanthos*.

CECIDOMYIA HOLOTRICHA Osten-Sacken.*Cecidomyia holotricha*—

Osten-Sacken, Mon. Dipt. N. Am., pt. I, p. 193.

Glover, MS. Notes from my Journal, pl. XI, Fig. 23.

Beutenmüller, Cat. of Gall Insects, 1892, p. 266.

Beutenmüller, Amer. Mus. Jour. Vol. IV, No. 4, 1904, p. 26.

A small sub-globular or onion-shaped, pubescent, monothalamous gall. Frequently so abundant on the underside of the leaf as to cause it to shrivel. Common on *Hicoria ovata*.

CECIDOMYIA TUBICOLA Osten-Sacken.*Cecidomyia tubicola*—

Osten-Sacken, Mon. Dipt. N. Am., pt. I, p. 192.

Glover, MS. Notes from my Journal, Dipt. pl. XI, fig. 25.

Beutenmüller, Cat. of Gall Insects, 1892, p. 267.

Beutenmüller, Amer. Mus. Jour. Vol. IV, No. 4, 1904, p. 27.

Small, cylindrical, monothalamous galls inserted in a concave protuberance on the underside of the leaf and very easily broken. Green, but when mature, a deep brown. Common on *Hicoria alba*. Also reported from New York.

CECIDOMYIA STROBILOIDES Osten-Sacken. Figs. 33, 34.*Cecidomyia strobiloides*—

Osten-Sacken, Mon. Dipt. pt. I, p. 203.

Walsh and Riley, Am. Ent. Vol. I, p. 105.

Packard, Guide to the Study of Insects, p. 377.

Glover, MS. Notes from my Journal, pl. XI, fig. 15.

Beutenmüller, Cat. of Gall Insects, p. 892, p. 267.

Beutenmüller, Amer. Mus. Jour. Vol. IV, No. 4, 1904, p. 25.

An apical, cone-shaped, bud gall formed of closely imbricated leaves. Makes its appearance in May and is fully grown in July. The mature insects do not emerge until early the following spring. Very abundant on the willows.

CECIDOMYIA SILIQUA Walsh.*Cecidomyia siliqua*—

Walsh, Proc. Ent. Soc. Phil. Vol. IV, p. 223-288.

This gall is a swelling of the young twigs and is about 1½ inches in length. It is monothalamous and contains a single larva.



Fig. 33.

CECIDOMYIA CLAVULA Beutenmüller.*Cecidomyia clavula*—

Beutenmüller, Cat. of Gall Insects, 1892, p. 269.

Beutenmüller, Amer. Mus. Jour. Vol. IV, No. 4, 1904, p. 29.

A club-shaped, monothalamous gall formed on the terminal twigs of *Cornus florida*. Same color as the twigs. I have collected this gall in Putnam County. It is also reported from New York.

CECIDOMYIA PILULÆ Walsh.*Cynips pilulæ*—

Walsh, Proc. Ent. Soc. Phil. Vol. II, p. 481.

Walsh and Riley, Am. Ent. Vol. II, p. 29.

Riley, 5th Rep. U. S. Com., p. 206.

Beutenmüller, Cat. of Gall Insects, 1892, p. 269.

Beutenmüller, Amer. Mus. Jour. Vol. IV, No. 4, 1904, p. 30.

A solid, fleshy, polythalamous gall occurring usually in great numbers on the upper surface of the leaf. On the under surface of the leaf opposite the gall is a small green projection of the leaf

structure. When young the gall is yellow or pale brown, but in August or September it becomes bright red or brown. The size is variable and frequently two or more galls unite. As it approaches maturity the surface cracks irregularly. On most species of the oak. Very widely distributed.

CECIDOMYIA SOLIDAGINIS Loew.

Cecidomyia solidaginis—

Loew, Mon. Dipt. N. Am. pt. I, p. 194.

Glover, MS. Notes from my Journal.

Beutenmüller, Bull. Amer. Mus. Nat. Hist. Vol. IV, No. 1, p. 271, 1892.

Beutenmüller, Amer. Mus. Jour. Vol. IV, No. 4, 1904, p. 31.

An apical gall which prevents the elongation of the stem and causes the leaves to be reduced and accumulated into a rosette mass. Very common on the golden-rods (*Solidago canadensis*).



Fig. 34.

SCIARA OCELLARIS Osten-Sacken. **Fig. 35.**

Cecidomyia ocellaris—

Osten-Sacken, Mon. Dipt. N. Am. pt. I, p. 199.

Glover, MS. Notes from my Journal.

Sciara ocellaris—

Comstock, Rep. U. S. Dept. Agricul., 1881, p. 202.

Packard, 5th Rep. U. S. Ent. Com., 1890, p. 411.

Beutenmüller, Bull. Amer. Mus. Nat. Hist. Vol. IV, No. 1,
1892, p. 273.

Beutenmüller, Amer. Mus. Jour. Vol. IV, No. 4, 1904, p. 33.

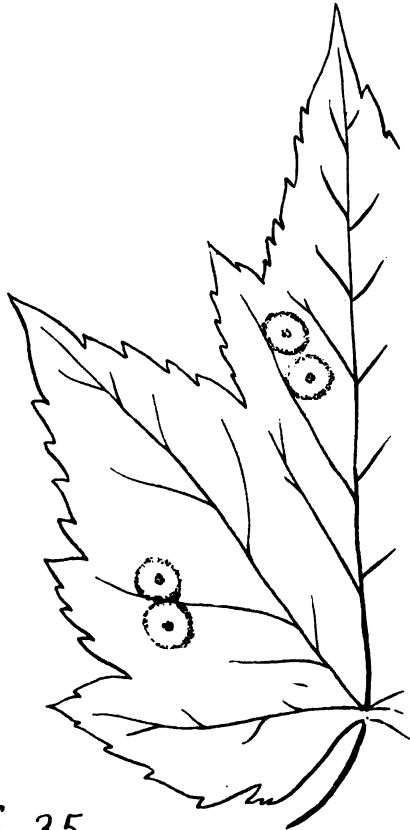


Fig. 35.

An eye-like, circular spot, light yellow in color with a red central dot. Frequently entirely green or yellow. Common on the red maple (*Acer rubrum*). Reported from New York. Probably as widely distributed as the host plant.

TRYPETIDÆ.

TRYPETA SOLIDAGINIS Fitch. Fig. 36.*Acinia solidaginis*—

Fitch, 1st Rep. Nox. Ins. Trans. N. Y. State Agricul. Soc.
Vol. XIV, p. 771.

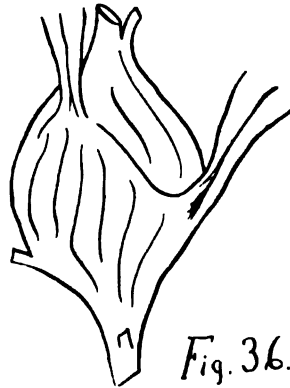
Trypeta solidaginis—

Loew, Mon. Dipt. N. Am., p. 82.

Glover, MS. Notes from my Journal.

Beutenmüller, Cat. of Gall Insects, p. 274.

Beutenmüller, Amer. Mus. Jour. Vol. IV, No. 4, 1904, p. 33.



A solid, spherical, monothalamous gall on the stem of the golden-rod (*Solidago canadensis*). Fully developed in August. The mature insect is as large or larger than the common housefly and emerges the following spring. Common and widely distributed.

HEMIPTERA.

PSYLLIDÆ.

PACHYSYLLA CELTIDIS-MAMMÆ Riley. Fig. 37.*Pachysylla celtidis-mammæ*—

Riley, Johnson's Universal Encyclopedia, 1876.

Riley, Can. Ent. Vol. XV, p. 158.

Riley, 5th Rep. U. S. Ent. Com., p. 620.

Fletcher, Rep. Ent. Soc., 1882, pp. 79, 80.

Packard, 5th Rep. U. S. Ent. Com., 1890, p. 615.

Beutenmüller, Cat. of Gall Insects, 1892, p. 275.

Beutenmüller, Amer. Mus. Jour. Vol. IV, No. 4, 1904, p. 35.



Fig. 37.

. A cylindrical, dense woody gall with bluntly rounded apex and slightly contracted at the point of attachment to the leaf. Always on the underside of the leaf. On the upper surface of the leaf opposite the gall is a concave depression. Very common on the hackberry (*Celtis occidentalis*).

APHIDÆ.

HORMAPHIS HAMAMELIDIS Fitch. *Fig. 38.

Byrsocrypta hamamelidis—

Fitch, N. Y. Cat. of Hom. Insects, 1851, p. 69.

Hormaphis hamamelidis—

Osten-Sacken, Stett. Ent. Zeitung, 1861, p. 422.

Walsh, Proc. Ent. Soc. Phil., VI, 1866-67, p. 281.

Hamamelistes cornu—

Shimer, Trans. Am. Ent. Soc., I, 1867, p. 283.



Fig. 38.

Hormaphis hamamelidis—

Thomas, Trans. Ills. State Hort. Soc., 1876-77, p. 199.

Beutenmüller, Cat. of Gall Insects, 1892, p. 276.

Beutenmüller, Amer. Mus. Jour. Vol. IV, No. 4, 1904, p. 36.

Pergande, The Life History of Two Species of Plant-Lice inhabiting both witch-hazel and birch, 1901, p. 7.

A conical, monothalamous gall produced on the upper surface usually at the angle formed by midrib and on the principal vein of the leaf. The opening on underside. Common on the witch-hazel (*Hamamelis virginica*.)

HAMAMELISTES SPINOSUS *Shimer. Fig. 39.*Hamamelistes spinosus*—

Shimer, Trans. Amer. Ent. Soc., Vol. I, p. 284, 1867.

Hormaphis spinosus—

Riley and Monell, Bull. U. S. Geol. Surv. Terr., Vol. V, No. 1, p. 14, 1879.

Hormaphis papyraceæ—Oestlund, Geol. and Nat. Hist. Surv. of Minn. Bull. 4.
Synopsis of Aphidæ of Minn., p. 13, 1887.

Fig. 39

Hormaphis spinosus—

Beutenmüller, Cat. of Gall Insects, 1892, p. 276.

Beutenmüller, Amer. Mus. Jour. Vol. IV, No. 4, 1904, p. 25.

Hamamelistes spinosus—

Pergande, The Life History of two species of plant-lice inhabiting both the witch-hazel and birch, 1901, p. 25.

This gall is a deformed fruit bud. It is oblong, green and covered with long spines. At the base of the gall is a funnel-like exit. On *Hamamelis virginica*, but not so abundant as *H. hamamelidis*.

COLOPHA ULMICOLA Fitch. Fig. 40.*Bryocrypta ulmicola*—

Fitch, 5th Rep. Nox. Ins. Trans. N. Y. Agricul. Soc., 1858, p. 843.

Thelaxes ulmicola—

Walsh, Proc. Ent. Soc. Phil. Vol. I, p. 305.

Walsh, Am. Ent. Vol. I, p. 108.

* Pergandi gives a most excellent description of the life history of these two species. *H. hamamelidis* has seven generations and *H. spinosus* has six generations.



Fig. 40.

Colopha ulmicola—

Monell, Can. Ent. Vol. IX, p. 102.

Glyphina ulmicola—

Thomas, 3d Rep. Nox. Ins. Ill., p. 142.

Colopha ulmicola—

Riley, Bull. U. S. Geo. Sur. (Hayden), Vol. V, p. 9, 1879.

Beutenmüller, Cat. of Gall Insects, 1892, p. 276.

Beutenmüller, Amer. Mus. Jour. Vol. IV, No. 4, 1904, p. 37.

A cockscomb gall formed on the upper side of the leaf. The opening is on the under surface of the leaf. Green, frequently tinged with red. Very common and very widely distributed on the elm (*Ulmus Americana*).

PEMPHIGUS ULMI-FUSUS Walsh.*Pemphigus ulmi-fusus*—

Walsh, Am. Ent. 1: 106, 1861.

Thomas, Rept. Ent. Ills. 8: 153, 1880.

Oestlund, Aph. Minn. 24, 1887.

Packard, Forest Ins., 1890.

Hunter, The Aphidæ of N. A., Iowa Agricul. Ex. Station, 1901, p. 77.

A small conical-shaped gall, contracted at the point of contact with the leaf. Always on the upper surface, but with the opening on the under surface. Common on the elm (*Ulmus Americana*).

PEMPHIGUS POPULICAILIS Fitch. Fig. 41.*Pemphigus populicailis*—

Fitch, Rept. Ins. N. Y. 5: 845, 1859.

Walsh, Proc. Ent. Soc. Phil. 1: 305, 1861.

LeBaron, 3d Rep. Nox. Ins. Ill., p. 193, 1873.

Thomas, 3d Rep. Nox. Ins. Ill. (Trans. Dept. of Agricul., 1878), p. 149.

Walsh and Riley, Am. Ent. 1: 57, 245, 1880.



Fig. 41.

Henry, Am. Ent. 1: 205, 1880.

Oestlung, Aph. Minn., 21, 1887.

Packard, 5th Rep. U. S. Ent. Com., p. 471, 1890.

Osborn, Cat. Hem. Ia., 1892, p. 130.

Beutenmüller, Cat. of Gall Insects, 1892, p. 277.

Beutenmüller, Amer. Mus. Jour. Vol. IV, No. 4, 1904, p. 38.

Gillette and Baker, Hem. Colo., 1895, p. 115.

Hunter, The Aphididæ of N. A. Iowa Ex. Station, 1901.

A more or less irregular spherical gall at point of union of petiole and leaf. Opening closed by a twisting of the leaf against the gall. Collected by C. C. Deam in Wells County on *Populus deltoides*. Widely distributed and reported from New York on *Populus monilifera*, and from Illinois on *P. angulata*.

PEMPHIGUS POPULI-TRANSVERSUS Riley. Fig. 42.

Pemphigus populi-transversus—

Riley, Bull. U. S. Geol. Surv. 5: 15, 1880.

Osborn, Cat. Hem. Ia., 130, 1892.

Bruner, Rept. Nebr. Hort. Soc., 361, 1893.

Lintner, Rept. Ent. N. Y. 13: 361, 1899.

Oestlund, Aph. Minn. 21, 1887.

Gillette and Baker, Hem. Colo., 116, 1895.

Hunter, The Aphididae of N. A., Iowa Ex. Station, 1901.

Packard, 5th Rep. U. S. Ent. Com., p. 434, 1890.



Fig. 42

An oval gall formed on one side of the petiole and causing it to become curved. On the side opposite the petiole is the slit opening which is sometimes contracted into a circular opening. Specimen collected by C. C. Deam in Wells County on cottonwood (*Populus deltoides*). Widely distributed and also occurring on *P. monilifera* and *P. balsamifera*.

PMPHIGUS VAGABUNDUS Walsh. Fig. 43.

Pemphigus vagabundus—

Walsh, Proc. Ent. Soc. Phil. I: 306, 1861.

Walsh and Riley, Am. Ent. I: 57, 100, 1861.

Packard, Forest Ins., 434, 1890.

Oestlund, Aph. Minn., 22, 1887.

Osborn, Cat. Hem. Ia., 130, 1892.

Cowen, in Hem. Colo., 116, 1895.

Hunter, The Aphididæ of N. A., Iowa Agricul. Ex. Station, 1901.

This an apical bud gall in which the leaves are so distorted as to have lost their identity as leaves. Each part is a double laminæ and between these two laminæ are large numbers of insects. I

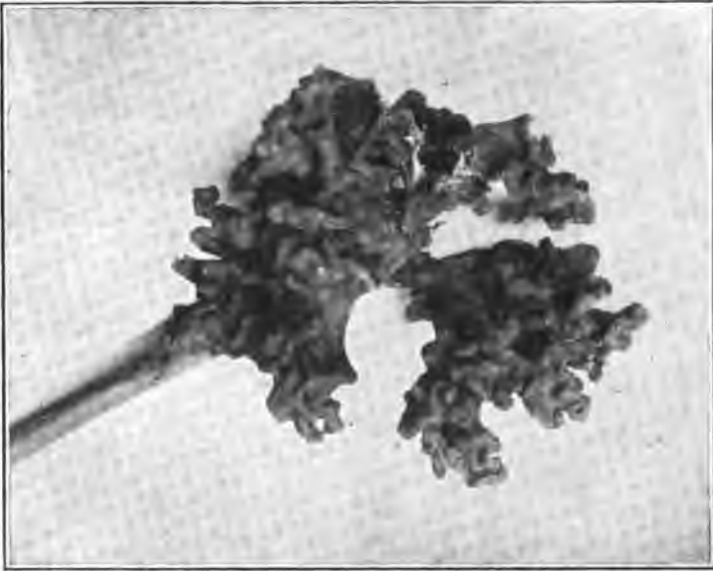


Fig. 43.

have frequently found a single fold in the leaf forming a gall very similar to *Colophya ulmicola*. I have collected this gall on the cotton wood (*Populus deltoides*) in Putnam County and Mr. F. C. Senour of New Augusta, Indiana, has sent specimens to me.

SCHIZONEURA AMERICANA Riley.

Schizoneura Americana—

Riley, Bull. U. S. Geol. and Geog. Surv., p. 4, 1879.

Packard, 5th Rept. U. S. Ent. Com., 1890, p. 279.

A wrinkling and rolling of the leaf of the common elm (*Ulmus Americana*). Very common and very widely distributed.

PHYLLOXERA CARYÆVENÆ Fitch.*Phylloxera caryævenæ*—

- Fitch, Rept. Ent. N. Y. 3: 444 (Pemphigus), 1856.
 Osten-Sacken, Stett. Ent. Zeit. 22: 421, 1861.
 Thomas, Rept. Ent. Ill. 8: 162, 1880.
 Oestlung, Aph. Minn. 18, 1887.
 Packard, Forest Ins. 322, 1890.
 Hunter, The Aphididæ of N. A. Iowa Agricul. Ex. Station,
 p. 71, 1901.
 Pergande, North Amer. Phylloxerinae, 1904, p. 239.

This gall is a folding of the leaf along the veins; the elevation being on the upper surface and the opening below. The opening is guarded with a mass of hair-like growth. Common on the hickory (*Hicoria alba*.)

PHYLLOXERA CARYÆ-GLOBULI Walsh.*Phylloxera caryæ-globuli*—

- Walsh, Proc. Ent. Soc. Phil. 1: 309, 1862.
 Walsh, Proct. Ent. 2: 120, 1867.

Dactylocphæra hemisphericum—

- Shimer, Trans. Am. Ent. Soc. 2: 387, 1869.

Phylloxera caryæ-globuli—

- Riley, Rept. Ins. Mo. 7: 117, 1875.
 Thomas, Rept. Ins. Ill. 8: 164, 1880.
 Oestlund, Aph. Minn. 18, 1887.
 Packard, Forest Ins. 322, 1890.
 Hunter, The Aphididæ of N. A. Iowa Agril. Ex. Station,
 1901.
 Pergande, North Amer. Phylloxerinae, 1904, p. 222.

A hemispherical-shaped gall on the upper surface of the leaf, opening on the under surface by means of a narrow slit. Frequently one-fourth inch in diameter. Common on hickory (*Hicoria alba*).

PHYLLOXERA CARYÆ-FALLAX Walsh. Fig. 44.*Phylloxera caryæ-fallax*—

- Walsh, Rept. Ent. Ill. 1: 23, 1868.
 Thomas, Rept. Ent. Ill. 8: 164, 1860.

Riley, Rept. Ins. Mo. 6: 118, 1874.

Oestlund, Aph. Minn. 18, 1887.

Packard, Forest Insects, 323, 1890.

Hunter, The Aphidæ of N. A., Iowa Agril. Ex. Station, 1901.

Pergande, North Amer. Phylloxerinae, 1904, p. 214.



Fig. 44.

A cone-shaped gall on the upper surface of the leaf. Opening is through the apex of a much shorter cone on the under surface of the leaf. Frequently so abundant as to seriously injure the foliage. Common on the hickory (*Hicoria alba*.)

PHYLLOXERA CARYÆ-CAULIS Fitch. Fig. 45.*Phylloxera carya-caulis*—

Fitch, Rept. Ins. N. Y. 1: 155-159 (*Pemphigus*), 1855.

Osten-Sacken, Stett. Ent. Zeit. 22: 421, 1861.

Riley, Rept. Ins. Mo. 117, 7: 1875.

Thomas, Rept. Ent. Ill. 8: 160, 1880.

Oestlund, Aph. Minn. 18, 1887.

Packard, Forest Insects 322, 1890.

Hopkins, Can. Ent. 28: 243, 1897.

Hunter, The Aphididae of N. A., Iowa Agril. Ex. Station 70, 1901.

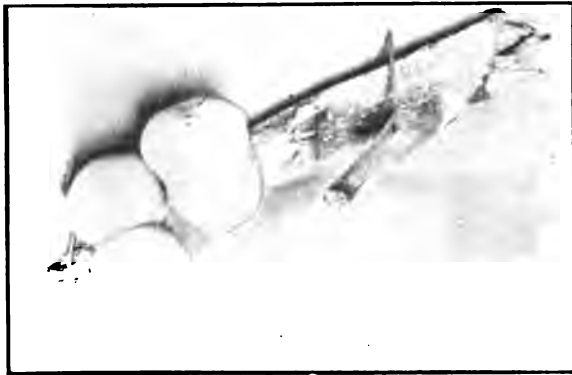


Fig. 45.

Dactylosphara subellipticum—

Shimer, Trans. Am. Ent. Soc. 2: 387, 1869 (Riley).

Dactylosphara caryæmagnum—

Shimer, Trans. Am. Ent. Soc. 2: 391, 1869 (Riley).

Pergande, North Amer. Phylloxerinae, 1904, p. 244.

A hemispherical gall, variable in size, on stem, petiole or ribs of the leaves. A small opening in the summit. Extremely variable. I have sometimes found these galls very large, completely surrounding the stem and with no visible opening, but completely filled with insects of various ages. Common on the hickory (*Hicoria alba*).

PHYLLOXERA CARYÆ-DEPRESSA Shimer.*Dactylosphæra coniformis*—

Shimer, Trans. Am. Ent. Soc. 2: 397, 1868.

Phylloxera caryæ-depressa—

Shimer, Trans. Am. Ent. Soc. 2: 390 (*Dactylosphæra*), 1868.

Riley, Rept. Ins. Mo. 7: 118, 1875.

Lintner, Rept. Ins. N. Y. 6: 189, 1889.

Oestlund, Aph. Minn., 18, 1887.

Packard, Forest Ins. 323, 1890.

Hunter, The Aphididæ of N. A., Iowa Agril. Ex. Station, 1901.

Pergande, North Amer. Phylloxerina, 1904, p. 208.

A depressed leaf gall similar to *P. caryæ-globuli*, but much more depressed. The gall is on the upper surface of the leaf and the opening below. The opening fringed with hair.

PHYLLOXERA VASTRATRIX Planchon. Figs. 46, 47.*Phylloxera vastratrix*—

Planchon, Comp. Rend. Acad. Sci., Paris, Sept. 14, 1868.

Riley, Rept. Ins. Mo. 7: 117, 1875.

Osborn, Cat. Hem. Ia. 130, 1892.

Hunter, The Aphididæ of N. A., Iowa Agril. Ex. Station, 1901.

Phylloxera vitifoliæ—

Fitch, Rept. Ins. N. Y. 1: 158, 1855.

Fitch, Rept. Ins. N. Y. 3: 117, 1856.

Walsh, Proc. Ent. Soc. Phil. 1: 305 (*Bysocrypta*), 1862.

Shimer, Proc. Acad. Nat. Sci. Phil., 1867.

Thomas, Rept. Ent. Ill. 8: 158, 1880.

Oestlund, Aph. Minn. 18, 1887.

Riley, Rept. Ent. Mo. 7: 117, 1875.

A small rough gall on either upper or lower surface of the leaf, but most often upon the upper. Frequently the leaves are absolutely covered with this gall and its usefulness to the plants practically destroyed. Another generation of this insect forms galls upon the roots and it is in this stage that it causes considerable

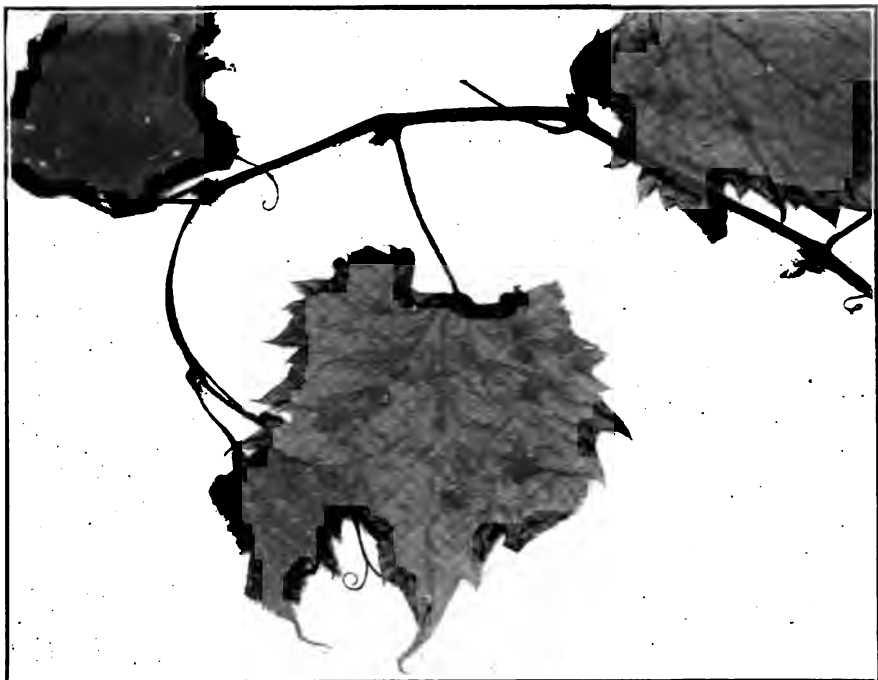


Fig. 46.

destruction among many varieties. Attacks a great many species and varieties. Common on many of our wild and cultivated grapes. The writer has collected it on *Vitis vulpina* and *V. bicolor*. Widely distributed throughout North America and Southern Europe.

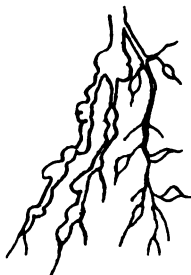


Fig. 47

LEPIDOPTERA.

GHLECHIDÆ.

GNORIMOSCHEMA GALLÆSOLIDAGINIS Riley. Fig. 48.*Gelechia gallæsolidaginis*—

Riley, Mo. Rep. Nat. Inst. I, 1869, p. 173.

Riley, Mo. Rept. Nat. Inst. II, 1870, pp. 20, 132, 134.

Smith's List Lep. Bor. Am., No. 5377, 1891.

Chambers, Can. Ent., VIII, 1876, p. 19.

Chambers, Can. Ent., IX, 1877, p. 14.

Cinn. Quart. Journ. Sci. II, 1875, p. 289.



Fig. 48.

Bull. U. S. Geol. Surv., III, 1877, pp. 1, 28, 141.

Bull. U. S. Geol. Surv. IV, 1878, pp. 115, 143.

Kellicott, Can. Ent., X, 1878, p. 201.

Dietz, Smith's List Inst. N. Jersey, 1900, p. 474.

Gnorimoschema gallæsolidaginis—

Busck, Proc. U. S. Nat. Mus. XXIII, 1900, p. 227.

Dyar's List Amer. Lep. No. 5620, 1903.

Proc. U. S. Nat. Mus. XXXI, p. 824.

A large elongated stem gall with very large larval chamber containing a single large larva. Very common on golden-rods (*Solidago canadensis*).

ARACHNIDA.

ERIOPHYIDÆ. (PHYTOPTIDÆ).

ACARUS SEROTINÆ Beutenmüller. **Fig. 49.**

Acarus serotina—

Beutenmüller, Cat. of Gall Insects, 1892, p. 278.

Beutenmüller, Amer. Mus. Jour. Vol. IV, No. 4, 1904, p. 38.



Fig. 49.

A pouch-like gall about two-fifths inch in length, connected with the upper side of the leaf by means of a constricted neck. The opening on the underside of the leaf. Common on the wild cherry (*Prunus serotina*).

ACARUS SEMEN Walsh.

Cecidomyia salicis-semen—

Walsh, Proc. Ent. Soc. Phil. Vol. III, pp. 543-644.

Acarus semen—

Walsh, Proc. Ent. Soc. Phil. Vol. IV, pp. 223-288.

A small gall with roughened surface usually occurring on the upper, occasionally on the lower surface of our common willows. The opening on the opposite surface from the gall.

ACARUS ÆNIGMA Walsh.*Cecidomyia salicis ænigma*—

Walsh, Proc. Ent. Soc. Phil. III, pp. 543-644.

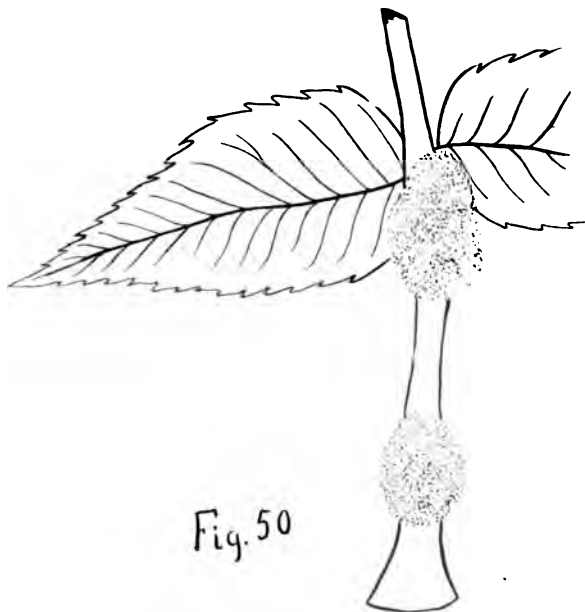
Acarus ænigma—

Walsh, Proc. Ent. Soc. Phil. IV, pp. 223-288.

A large leaf gall made up of a core covered with small filamentous structures which in old galls are frequently so fine as to be almost silky in appearance. In some cases only a part of a single leaf will be affected, at other times the entire leaf and sometimes the mass of leaves from a single leaf bud will be affected, thus producing a large gall which may remain on the tree during the entire winter. Common on the willows.

ACARUS CAULIS Walsh. • Fig. 50.

A reddish, later brownish swelling covered with woolly pubescence found on the petiole, ribs and large veins of the leaves of



our black walnut (*Juglans nigra*) and causing a bending of the parts affected. Frequently so common as to be injurious to young trees.

*I have been unable to secure satisfactory bibliography of this gall. It seems to be the same as described by Walsh and referred to in Proc. Ent. Soc. of Phil., Vol. III, p. 227. Miss L. J. Martin, in a paper on "Botanical Study of the Mite Gall on the Black Walnut," 1885, gave a discussion of the morphology. It is frequently referred to as *Erineum Anomium*.

ERIOPHYES QUADRIPIPES Shimer.*Vasates quadripes*—

Shimer, Trans. Amer. Ent. Soc., May, 1869.

Phytoptus quadripes—

Osborn, Western Stock Jour. and Farmer, Vol. 9, p. 142, 1879.

Osborn, Bull. Iowa Agric. College, No. 2, pp. 54-61, Aug., 1884.

Osborn, Trans. Iowa State Hort. Soc., Vol. 18, pp. 127-135.

Garman, 12th Rep. Ills. State. Ent., 1882.

Lintner, Cult. and Country Gentl., Vol. 53, p. 430, 1888.

Packard, 5th Rept. U. S. Ent. Com., 1890.

Murtfeldt, Colman Rural World, April 25, 1895, p. 131.

Felt, Country Gentl., June 1, 1899, p. 430.

Felt, Country Gentl., June 22, 1899, p. 486.

Eriophyes quadripes—

Banks, Proc. Nat. Mus. Vol. XXVIII, p. 106.

Small galls, varying somewhat in size, usually discoidal or spherical on the upper side of the leaf and connected with it by a slightly constricted neck. In the spring and summer about the same color as the leaf, but in the late summer or fall becoming purplish and finally black and dry. Common on our soft maple (*Acer saccharinum*).

ERIOPHYES ACERICOLA Garman.*Phytoptus acericola*—

Garman, 12th Rep. Ills. State. Ent., 1882.

Packard, 5th Rept. U. S. Ent. Com., p. 424, 1890.

A small spindle-shaped gall about one-fifth inch in length attached to the upper surface of the leaf by one end. Same color as leaf, sometimes reddish or purplish. Common on our soft and sugar maples (*Acer saccharinum* and *A. saccharum*.)

ERIOPHYES ABNORMIS Garman. Fig. 51.*Phytoptus abnormis*—

Garman, 12th Rept. Ills. State Ent., 1882.

Phytoptus abnormis—

Packard, 5th Rept. U. S. Ent. Com., p. 480, 1890.

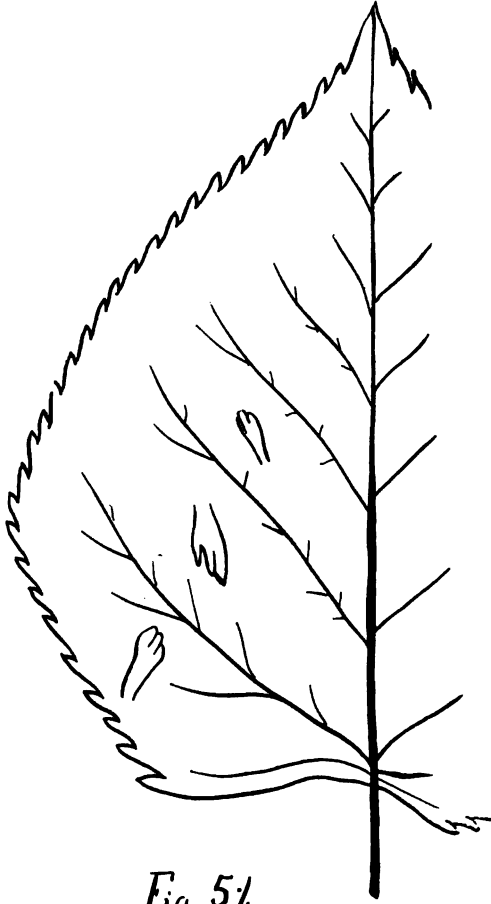


Fig. 51.

An elongated club-shaped gall, attached to the upper, occasionally lower, surface of the leaf by the small end. The walls deeply infolded and notched at the end. Same color as the leaf. Common on the linden or bass wood (*Tilia Americana*).

ERIOPHYES ULMI Garman.

Phytoptus ulmi—

Garman, 12th Rept. Ills. State Entomol., 1882.

Phytoptus ulmi—

Packard, 5th Rept. U. S. Ent. Com., p. 281, 1890.

A small more or less spherical gall with slightly constricted neck occurring very abundantly upon the upper surface of our elms (*Ulmus Americana*).

ERIOPHYES FRAXINI Garman.*Phytoptus fraxini*—

Garman, 12th Rept. State Ent. of Ills., 1882.

Packard, 5th Rept. U. S. Ent. Com., p. 554, 1890.

A small irregular more or less spherical gall occurring on the upper surface of the leaves of our common green ash (*Fraxinus viridis*). A similar gall also occurs on the green ash (*F. Americana*).

ERIOPHYES SALICICOLA Garman.*Phytoptus salicicola*—

Garman, 12th Rep. Ills. State. Ent., 1882.

A small, rather irregular more or less spherical gall occurring in great abundance on the upper surface of the leaves of willow (*Salix* sp. —).

ERIOPHYES sp.*Phytoptus* sp.—

Garman, 12th Rep. Ills. State. Ent., 1882.

A small, more or less irregular, spherical gall which very frequently unites with its neighbor into large patches on the upper surface of the leaves of the poison ivy (*Rhus toxicodendron*).

ERIOPHYES sp.—, and SPHÆROTHECA PHYTOPTOPHILA Kell and Sw. Fig. 52.*Phytoptus* sp.—, and *Sphærotheca phytoptophila*—

Kell and Sw., Kan. Agri. Ex. Station Rept., 1888, pp. 302-315.

Sphærotheca phytoptophila—

Kell and Sw., Journal of Mycology Vol. IV (1888), pp. 93-94.

An Eriphyes and fungus associated and forming a witch-broom gall on hackberry (*Celtis occidentalis*). These galls are very numerous on the branches and twigs and range from 1/2 to 1 1/2 inches in diameter and each gives rise to a large number of smaller twigs. They injure the tree by causing unsightly disfigurations, loss of nourishment in forming galls, and give points of decay which sometimes extend to the trunks and cause the death of the tree.



Fig. 52.

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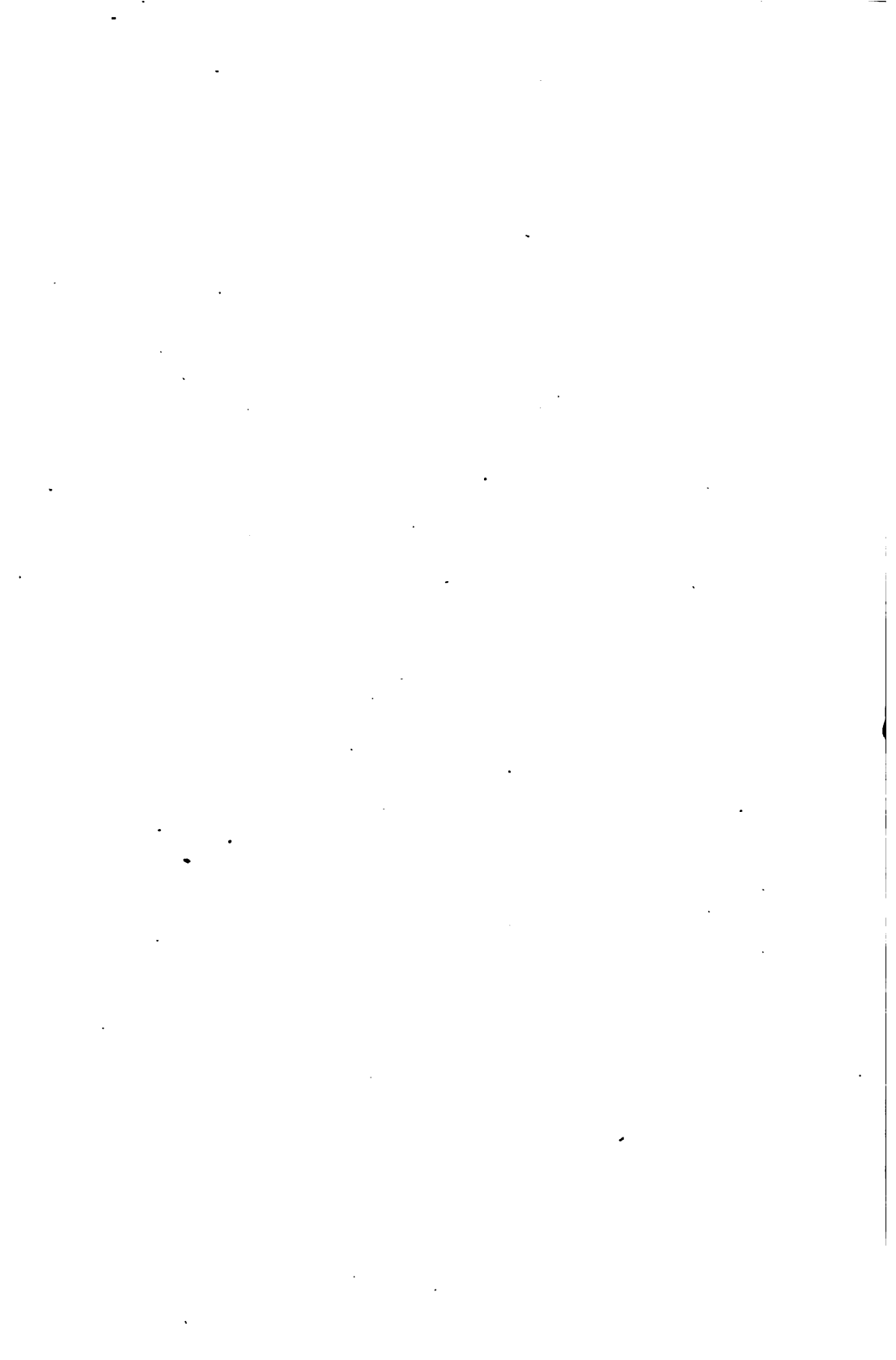
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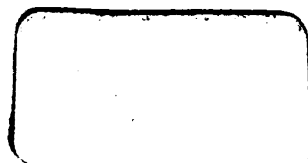
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